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Cover.—The production of kamaboko (see pages 1-15) is a big business in Japan. Kamaboko is also produced in small quantities in the United States. On the cover kamaboko is seen on racks for cooling in a factory in Hawaii.

U.S. DEPARTMENT OF COMMERCE
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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MFR PAPER 1019

"Kamaboko," an immensely popular staple in the Japanese diet, gives U.S. fishery products researchers food for thought.

"Kamaboko"—The Giant Among Japanese Processed Fishery Products

MINORU OKADA, DAVID MIYAUCHI, and GEORGE KUDO

ABSTRACT

About 25 percent of the Japanese fish catch is processed into "Kamaboko," an elastic heat-pasteurized fish cake. In 1970, over 1 million metric tons of "Kamaboko"-type products were produced. To make "Kamaboko," the fish muscle is separated mechanically from skin and bones, washed, and mixed with other ingredients while being ground into a sticky paste. The fish paste is then shaped and heat-pasteurized. The authors describe factors affecting the quality of of "Kamaboko."

INTRODUCTION

The fish catch of the United States in 1970 totaled 2,758,300 metric tons, of which about 66 percent was utilized as food. About 40 percent of the total catch was marketed fresh or frozen, 24 percent was canned, and 2 percent was cured. Even though the per capita consumption of fishery products remains at about 10 to 12 pounds, the consumption of fishery products in the United States has been increasing owing to the increase in population.

Most species of fish for which a strong consumer demand exists are fished intensively. Many are overfished. To provide for this increasing demand, we must therefore look toward those few resources that remain underutilized and develop methods of preservation and processing into products that will be attractive to the domestic consumer.

In comparison, the consumption of fish in Japan is among the highest per capita in the world. The fish catch of Japan in 1970 totaled 9,314,300 metric tons, of which 80 percent was utilized as food (Figure 1). The Japanese use several hundred different species of fish to produce a wide variety of processed fishery products. Dependence on seafood as the principal source of animal protein has resulted in the use of this protein in many ways that are unique to the Japanese. Some of these products and processing procedures could have application to the use of the fishery resources of the United States for food. This paper is the first in a series to describe some Japanese fish products, processing techniques, and how we might apply them in the United States.

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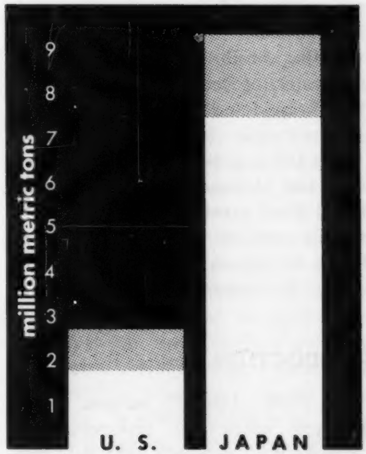


Figure 1.—The U.S. fish catch in 1970 totalled 2.7 million metric tons, of which about 66 percent (unshaded area) was utilized as food; the 1970 fish catch in Japan totalled 9.3 million metric tons, of which 80 percent (unshaded area) was utilized as food.

The products that may be of most interest to American food processors appear to be "Kamaboko" and fish sausage. "Kamaboko" and fish sausage are produced by grinding raw fish muscle with salt and other ingredients

and then cooking. They are marketed in a variety of forms, textures, flavors, and even colors. All of these properties can be modified to suit the demands of U.S. consumers. This paper describes the preparation and properties of "Kamaboko"—a Japanese-style fish cake.

The Japanese word "Kamaboko" is used in two ways. As a generic term, it is the name of an elastic or rubbery Japanese-style fish cake. As a specific term, kamaboko (used in this paper with no quotation marks) is the name of a particular type of fish cake.

"Kamaboko," the elastic fish cake, is made with ground fish muscle as the principal ingredient; starch as a thickening agent; and sugar, salt, and monosodium glutamate for flavoring. The mixture is heat-pasteurized by steaming, broiling, immersing in boiling water, or deep-fat frying. "Kamaboko" is described by others as a Japanese-style fish paste (Tanikawa, 1971) and as a fish product resembling meat loaf (Amano, 1965). It is a traditional food relished by the Japanese and its method of production can be found in written Japanese documents of the 15th century.

PRODUCTION

In 1968, about 25 percent of the Japanese catch was processed into "Kamaboko" products and fish sausages. Close to 1 million metric tons of product were made as follows (Tanikawa, 1971):

Product	Production (metric tons)
Chikuwa	194,035
Kamaboko	336,365
Satsumaage	289,501
Fish sausage and hams	161,753
Others	17,722
Total	999,376

In comparison, the total production of these products in 1958 was 436,592 metric tons (Figure 2) and in 1970 was 1.08 million metric tons (Anonymous, 1971).

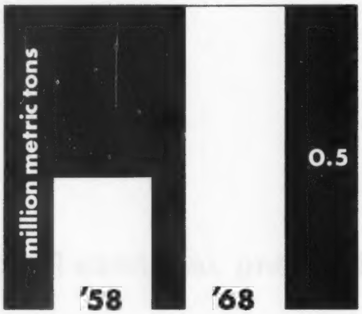


Figure 2.—Production of "Kamaboko" products and fish sausages in Japan more than doubled from 1958 to 1968.

The following factors were instrumental in the rapid growth of "Kamaboko" production:

1. With the recent rise in incomes, changes in the dietary patterns resulted in a greater consumption of proteinaceous and ready-to-eat types of foods.
2. Appearance and flavor of "Kamaboko" can be easily altered to meet consumer demands by adding various ingredients to the minced flesh.
3. Underutilized species and fish having low acceptance because of flavor deficiencies or poor appearance in the fresh state can be used successfully as raw materials.
4. Recent development in processing machines permits large-scale production.
5. Keeping quality has been improved with recent advances in packaging and processing.
6. Basic studies on fish muscle protein have hastened the development of a technology that improves quality and the economics of production.

TYPES OF "KAMABOKO"

"Kamaboko" is made in various shapes, colors, and flavors depending upon the ingredients and heating methods used. The three main types are as follows:

1. Kamaboko (used as a specific term): a fine-textured white elastic fish cake that is mounted on a small board and cooked by steaming and/or broiling.
2. Chikuwa: a tubular-shaped fish cake, which is cooked by broiling.
3. Satsumaage: a deep-fat fried fish cake made in various shapes such as a ball, square, disk, or cylinder.

MANUFACTURING PROCEDURE FOR "KAMABOKO"-TYPE PRODUCTS

In making "Kamaboko," the muscle from headed-and-gutted fish is separated from skin and bones, washed with water, and mixed with other ingredients while being ground into a homogeneous sticky paste. The fish paste is then shaped and heated.

Separation of Flesh

The fish are headed and eviscerated. After washing, the headed-and-gutted fish are put through a flesh-separator machine, which has either a perforated steel drum or plate and a press. The fish is passed under the press, which forces only the muscle through small holes of the perforated drum or plate, thus conveniently and effectively separating muscle from skin and bones.

The yield of minced flesh depends on the pressure applied to crush the fish as well as on the species of fish used. The yields of flesh from Pacific Ocean fish using a small drum-type separator varied from about 28 percent for Pacific cod to 66 percent for Pacific herring (Miyauchi and Steinberg, 1970).

Washing the Flesh

The separated minced flesh is washed well with chilled water to remove blood, flesh pigments, mucus, and fat. Washing improves the color and odor of the muscle and significantly improves the elasticity of the processed product.

One part by weight of flesh is stirred with five to seven parts by weight of water in a tank, the flesh is allowed to settle, and the supernatant

is removed. The same volume of chilled water is added again to the flesh and stirred. The washing operation is repeated three to five times. The washed flesh is dewatered by pressing or centrifuging.

Grinding Fish Muscle with Ingredients

The dewatered minced flesh is reduced to a pulp in a meat chopper and then ground with salt and other ingredients in a stone mortar for 30 to 50 minutes. The stone mortar has three or four pestles which rotate while pressing the inside of the mortar. By the kneading and crushing action of the pestles, the texture of the muscle is gradually demolished and ingredients are mixed uniformly into a sticky paste. The temperature of the flesh mixture is kept below 15 °C (59°F) during this grinding by using prechilled or refrigerated stone mortars, which serve to absorb the heat generated during this operation.

The ingredients used in "Kamaboko" vary widely according to the type of product, the cost, or the locality of the production. Salt content ranges from 2.5 to 4 percent. Lower salt content results in poor texture, and a higher content gives too salty a taste. Sugar and monosodium glutamate are most commonly used as flavoring ingredients. Sodium inosinate, flesh extractives, or "mirim" (specially flavored rice wine) are also used as flavor intensifiers. Egg white is added to improve the glossiness of the product. Starch is added when necessary to improve elasticity of the product. More starch is used in cheaper products because starch enables the addition of as much as two to three times its weight of water while maintaining the desired cohesiveness.

Shaping

"Kamaboko"-type products are made into different shapes and sizes by machines. Each of the three main types—kamaboko, chikuwa, and satsumaage—has its own shaping machine. The ground fish paste is shaped as soon as possible after preparation because the fish paste often sets, if stored, and then cannot be shaped. Since setting occurs more rapidly at higher temperatures, the fish paste is kept chilled to prevent setting.

Cooking

Three main types of cooking processes are used: steaming, broiling, and deep-fat frying.

Steaming is used for most kamaboko today; the raw kamaboko on the wood board is cooked continuously as it is conveyed through the steam box.

Broiling, formerly the cooking process for all kinds of "Kamaboko," is now used mainly for chikuwa, the tubular fish cake, and for a high quality "Kamaboko" called "yakinuki kamaboko" (broiled kamaboko).

Deep-fat frying is used for satsumaage. Soybean, rapeseed, and sesame seed oils are the usual frying oils.

After cooking, the fish cakes are rapidly cooled and packaged.

FACTORS AFFECTING QUALITY OF "KAMABOKO"

Elastic Quality or "Ashi"

The distinctive eating characteristic of "Kamaboko" is its elastic quality, called "ashi" in Japanese. Elasticity and flexibility are the basic characteristics of a good "ashi." In addition to being a determining factor of the eating quality, "ashi" also affects the appearance, especially glossiness, and the keeping quality. "Kamaboko" with better "ashi" has better appearance and better keeping quality.

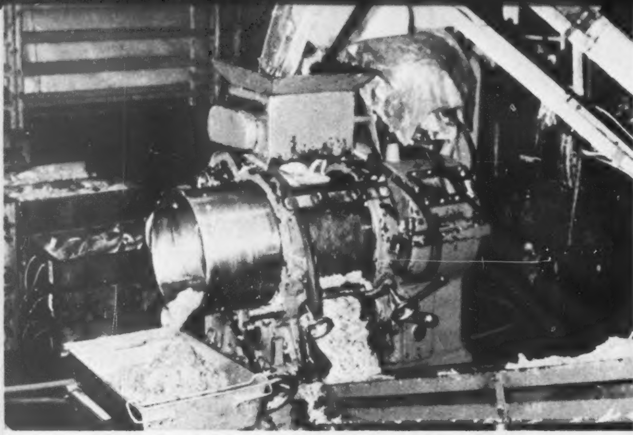
The "ashi" of "Kamaboko" depends on factors such as the species of fish used, freshness of the fish, and processing techniques. The best quality "Kamaboko" is produced from fish that have the proper gel-forming capacity and by the use of good established processing techniques.

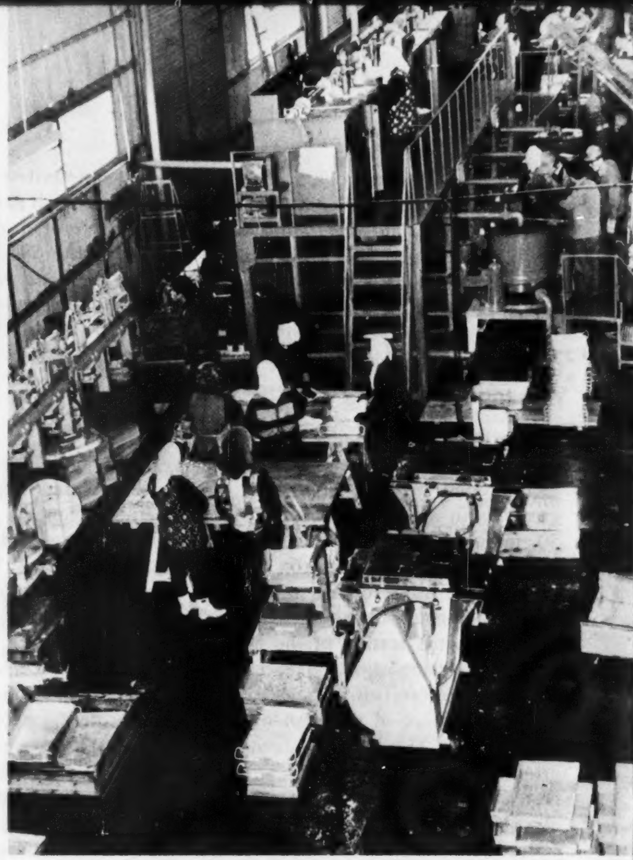
Species

It is well known that "ashi" or elasticity of "Kamaboko" made from different species of fish varies greatly. For example, fish such as black marlin or croaker will make a very elastic product but many small pelagic fish and fatty fish such as sardines, mackerel, or saury will make products with very poor elasticity. Some of these fatty fish immediately after death, however, will make good elastic products, but their "Kamaboko"-forming capabilities decrease rapidly after rigor mortis sets in. After these fish have been iced for two or three days, they make only a crumbly product.

Lizardfish is considered one of the best raw materials for "Kamaboko" in those areas where fish can be caught in nearby waters and can be processed soon after catching; but lizardfish loses its high "Kamaboko"-forming capabilities within three or four days of iced storage after catch. The gel-forming capability of black marlin and croaker, on the other hand, is not markedly affected by their freshness. Even after being iced for periods as long as two or three weeks, they make an elastic "Kamaboko." Thus, the classification of species on the basis of their "Kamaboko"-forming capabilities is not easy. Fish having good gel-forming capability irrespective of freshness are regarded as the best raw material; and fish whose gel-forming capability is rapidly lost after catch are considered an inferior raw material. The suitability of a species for making "Kamaboko" must be judged by the functional properties of the muscle proteins at the time the fish is processed into "Kamaboko."

According to experienced "Kamaboko" producers, the age of the fish, fishing ground, and the time of year are important factors. Young fish have better "Kamaboko"-forming capability than old fish, and fish immediately after spawning have the lowest "Kamaboko"-forming capability.





Some of the various parts of the process in producing surimi and "Kamaboko," from top left, counterclockwise: Flesh separation by machine; surimi ready for packing in polyethylene bags; conveyer bringing "Kamaboko" from continuous cooker; cooling "Kamaboko"; storage of frozen surimi; a view of the interior of a Japanese surimi and "Kamaboko" plant (1967 model) including wash tanks for extruded flesh, a centrifuge, hydraulic press, strainer, and block former.

Relation of "Ashi" to Extractability of Myofibrillar Proteins

"Kamaboko" with good "ashi" is produced from fish muscle containing nearly maximum amounts of extractable myofibrillar protein. It cannot be produced from denatured muscle proteins such as those found in dried, salted, or poorly stored frozen fish.

A concentration between 1.2 and 1.5*M* NaCl gives maximum extraction of myosin from fish muscle as well as the best resiliency in the finished product (Shimizu et al., 1954; Shimizu and Simidu, 1955). The use of salt at these concentrations, however, would make the product too salty, and 2.5 to 3.5 percent (0.4 to 0.6 *M*) NaCl is used in the commercial "Kamaboko" production. The enhancing effect of polyphosphates on the elasticity of the product is attributed in part to their ability to extract myofibrillar proteins.

Formation of Network Structure

Elasticity of the finished product is also a function of cooking temperatures (Okada, 1959). "Ashi" is usually the poorest when the fish paste is cooked between 60°C (140°F) and 65°C (149°F) and is best when cooked rapidly at higher temperatures. This suggests that there is another important factor besides extraction of myofibrillar proteins that influences the elasticity of "Kamaboko." This factor is the formation of a network of myofibrillar proteins. The threadlike shapes of the myofibrillar proteins are suitable for building up the network structure of "Kamaboko." The increase in elasticity that results from the addition of very small amounts of oxidants indicates the existence of such a structure (Okada and Nakayama, 1961). Thus, the addition of 0.1 to 0.2 percent potassium bromate to horse mackerel muscle during grinding with salt improves the jelly strength of the cooked product. Comparative measurements of elasticity and the content of free sulfhydryl groups of "Kamaboko" showed that elasticity is increased as free sulfhydryl groups are decreased by the addition of bromate. The effectiveness of bromate might be attributed to crosslinking of polypeptide chains by the reaction:

$$-SH + -SH \longrightarrow S-S$$

Thus, formation of good "ashi" requires both the extraction of myofibrillar proteins from the muscle and the formation of a network structure of the extracted proteins.

Water-Soluble Proteins and "Ashi"

Elasticity of "Kamaboko" can be improved significantly by washing the muscle before grinding. A large amount of the fat and water-soluble substances can be removed from the muscle by the washing process. The improvement in "ashi" of the product, however, is not attributable to the removal of fat because no significant decrease in "ashi" is observed by the addition of as much as 10 percent fat to the washed muscle. Okada (1964) has demonstrated that water-soluble proteins have deleterious effects on "ashi" formation. When concentrated water-soluble substances were added to the washed muscle, a significant decrease in "ashi" of "Kamaboko" was observed. Removal of the water-soluble protein from concentrated washings by heat coagulation before addition to the washed flesh produced no decrease in "ashi" of the "Kamaboko." The explanation has been offered that the water-soluble proteins reduce the elasticity of the "Kamaboko" by interrupting the continuum of cross-linked myofibrillar proteins or by interfering with the cross-linking process itself. It has also been proposed that proteolytic activity of the water-soluble protein fraction may adversely affect the ability of the myofibrillar protein to form cross-linkages.

KEEPING QUALITY OF "KAMABOKO"

Keeping quality of "Kamaboko" depends on a variety of factors but the ingredients used, processing temperatures, and packaging seem to be critical.

Ingredients

Owing to the nature of minced flesh, the potential for high bacterial contamination of the minced flesh during processing exists. Chilling, rapid handling, and thorough cleaning of the fish and good sanitation practices are essential for keeping the microbiological load of the minced flesh low. Other ingredients, in addition to the fish, affect keeping quality.

Kimata (1951) found that different types of spoilage of "Kamaboko" were due to the kinds and amounts of carbohydrates (sugar or starch) used as ingredients. Several investigators (Kimata and Kawai, 1951; Kimata and Sosogi, 1956; and Suzuki, 1959) have shown that starch is the primary source of thermotolerant bacteria responsible for spoilage. Potato starch, among the starches, is reported to contain the largest number of bacteria (as high as 5.0×10^4 per g) with about 70 percent of them thermotolerant.

Processing Temperature

During the processing, the temperature at the center of "Kamaboko" is highest when broiled, next highest when deep-fat fried, and is lowest when steamed. In one study, Yokoseki (1958), starting with raw fish paste containing about 10^7 bacteria per gram, found a considerable number of surviving micrococci when the "Kamaboko" was cooked to an internal temperature below 70°C (158°F); found 1.3×10^4/g of aerobic spore-forming rods of *Bacillus* species and no anaerobes in "Kamaboko" cooked to 75°C (167°F); and found only 6.0×

10^1/g of aerobic *Bacillus* in "Kamaboko" cooked to an internal temperature of 85°C (185°F). On the other hand, he usually found cocci in "Kamaboko" with starch cooked to an internal temperature below 70°C and found survivors that were mainly strict aerobic organisms such as *Bacillus megatherium*, *B. subtilis*, and *B. cereus* in those cooked to an internal temperature of 75°C and higher. Commercially, "Kamaboko" is cooked to an internal temperature about 75°C to give the product good keeping quality.

Packaging

Prevention of contamination by microorganisms in the air by packaging "Kamaboko" before or immediately after cooking is very effective in improving the keeping quality. Even a simple package such as a cellophane overwrap can increase the keeping quality as much as twofold. Vacuum packaging with laminated cellophane is a much better means of preventing bacterial growth. After vacuum packaging, the product is cooked again to kill the bacteria on the packaging material as well as the bacteria in the product.

The most effective method of preventing bacterial contamination is sealing the raw flesh paste tightly with a plastic film and then cooking above 75°C. The plastic film should be heat-resistant, gas- and water-impermeable, and heat-shrinkable. Vinylidene chloride fulfills these requirements. Fish sausage, a semi-processed food, is a product packaged by this method; fish paste is packed into a casing of vinylidene chloride, sealed tightly with aluminum wire, and finally cooked in a hot water bath at 85° to 90°C for about 50 minutes.

"KAMABOKO"-TYPE PRODUCT AND THE U.S. CONSUMER

"Kamaboko" and fish sausage are produced by mixing fish flesh with salt and other ingredients, shaping in various forms, and then cooking to get elasticity or cohesiveness. These products are higher in protein and lower in calories than many processed meat products, such as wieners and bologna. As each nation has its own food preferences, the flavor and texture of Japanese "Kamaboko" is not always appealing to others. Whereas the Japanese prefer a rubbery "Kamaboko"-type product, the Americans generally prefer a wiener-like, only slightly elastic product. The flavor, texture, and appearance of the "Kamaboko"-type products can be easily modified to suit the preferences of the U.S. consumer by blending various species of fish and by varying the other food ingredients to obtain the desired flavor, texture, and appearance. The results of our studies along these lines are presented in some of the following papers.

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MFR PAPER 1020

Head and gut fish, separate flesh from the skeletons, wash and dewater, strain, and add flavoring. That is the simplified recipe for . . .

Surimi—A Semi-Processed Wet Fish Protein

DAVID MIYAUCHI, GEORGE KUDO, and MAX PATASHNIK

ABSTRACT

The development of the technology for preparing surimi, a semi-processed wet fish protein, was responsible for the rapid increase in the production of "Kamaboko"-type products in Japan. By being processed into surimi, the fish muscle proteins retain for a longer time the functional properties required for making good "Kamaboko" and fish sausages. The preparation procedure and factors affecting the quality of surimi are described.

INTRODUCTION

In the preceding paper on "Kamaboko", the rapid increase in the production of "Kamaboko"-type products in Japan to over 1 million metric tons in 1970 was cited. This increase was made possible to a large extent by Japanese fishery scientists who developed the technology for preparing surimi, a semi-processed wet fish protein. In preparing surimi, the initial process steps are identical to those for preparing "Kamaboko": heading, gutting, and washing the flesh; separating the fish muscle from skin and bones; washing and dewatering the minced muscle; and straining. In the final process step, the strained muscle is mixed with various additives to stabilize the fish proteins during frozen storage. This mixture is packaged and frozen into rectangular surimi blocks.

The muscle proteins of many species of fish lose their "Kamaboko"-forming properties very rapidly once they are frozen. However, when the muscle is processed into surimi before freezing, the muscle proteins retain for a significantly longer time the functional properties required for making high quality "Kamaboko" and fish sausages. Until the procedure for making surimi was developed, the production of each "Kamaboko" processing plant was limited by the amount of fish muscle it could obtain from fresh fish. Now, "Kamaboko" processing plants can stockpile their raw material to assure full-scale production throughout the year. The surimi plants, which have been built in ports close to the fishing grounds, are mechanized for the efficient handling and processing of the fish into surimi. The compact frozen surimi block as a ready-to-use intermediate raw material is more economical for shipping to and storing at the "Kamaboko" plants in the larger cities than are whole fish.

The frozen surimi industry started in the northern Japanese island of Hokkaido on a small scale in 1960 but expanded greatly when equipment to produce surimi was installed aboard factory ships operating in the North Pacific and Bering Sea (Sakai, 1969). The production of surimi was 87,000 metric tons in 1967 and increased to 292,000 metric tons by 1970 (Zaidan Hojin Norin Tokei Kyokai, 1971). Of the 1970 production, the shore plants in Hokkaido and the Tohoku district in northern Honshu produced 153,000 metric tons of surimi and factory ships produced 139,000 metric tons, primarily in the Bering Sea.

PROCEDURE FOR MAKING SURIMI

The procedure for making surimi from Alaska pollock in a typical modern processing plant is described below.

Heading and Gutting Fish

Alaska pollock are headed and gutted by machine. Complete removal of the viscera, spine, and black peritoneum is required to produce a high quality finished product. The fish are taken by conveyor to a drum-type washer to remove slime, scales, blood, bits of viscera, and other extraneous material.

Separation of Flesh

From the washer, the headed-and-gutted fish are taken by conveyor to the first flesh-separator machine. There the fish pass between a press and a perforated drum. The relatively soft muscle is forced through the holes to the

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inside of the drum. The bones, skin, and adhering flesh remain on the outside of the drum and are scraped off onto a conveyor belt. This "waste" material from the first flesh separator is conveyed to the second flesh-separator machine, which effectively completes the separation of muscle from skin and bones. The minced flesh from the flesh separators is conveyed to a slurry tank where it is mixed with about an equal weight of water and pumped to flesh-washing tanks.

Washing and Dewatering the Minced Flesh

At the washing tanks, chilled water is added to the slurry at a ratio of five to ten parts of water to one part, by weight, of flesh and gently stirred to leach out blood, flesh pigments, and other water-soluble constituents as well as to float out much of the oil. The flesh is partially dewatered as it is conveyed through a rotary sieve. The washing step may be repeated several times as required. Because of the limited supply of fresh water, on factory ships the flesh-water ratio is 1:4 and only a single wash is used. The time of immersion and of stirring is automatically controlled. The washed minced flesh is then passed through a screw press for final dewatering. The pitch of the flights progressively increases toward the discharge end to increase pressure, and thus the water is gradually pressed from the minced flesh and passes through small holes in the jacket of the press. The desired water content of the dewatered flesh is about 84-86 percent.

Straining the Flesh

The minced flesh is then fed through a flesh strainer which removes small bones, connective tissue, black skin particles, scales, and tendons.

Mixing With Additives

The strained flesh is mixed in a food mixer or silent cutter with additives that retard denaturation of the fish protein during frozen storage. Nishiya (1963) showed that leaching the flesh with water to remove inorganic substances and water-soluble proteins, followed by the addition of sodium tripolyphosphate and sugars (sucrose, glucose, or sorbitol) inhibits the rate of denaturation of the proteins. Sucrose or sorbitol is added to surimi used in high-quality "Kamaboko" that requires white color. Glucose, which is less expensive, is added to lower grade surimi, which is used in fish sausage because the browning owing to the amino-carbonyl reaction is not an important factor in sausages. Thus, 5 percent sugar and 0.2 percent tripolyphosphate by weight of the minced flesh are added and mixed for 5-10 minutes until uniformly distributed. The temperature of the mixture must be kept below 50°F (10°C).

Table 1.—Grades for Alaska pollock (*Theragra chalcogramma*) surimi established by the Hokkaido Surimi Association in 1965.

Grades	Freshness of fish	Moisture content of washed flesh	Additives used				Amount of starch used in "Kamaboko" prepared for folding test[1]
			Sugar (sucrose)	Sorbitol	Glucose	Poly-phosphate	
		Percent					
SA (Special Grade A)	Day boat fish in rigor	79	—	5	—	0.2	0
A	Day boat fish post rigor	80	5	—	—	0.2	3
			—	5	—	0.2	
			—	—	5	0.2	
B	1- to 3-day iced fish	82	5	—	—	0.2	7
			—	—	5	0.2	
C	3- to 4-day iced fish	83	5	—	—	0.2	10
			—	—	5	0.2	

[1] Folding test: Surimi is processed into kamaboko with 3 percent NaCl and the indicated amount of starch; no cracks or breaks are permitted when pieces of kamaboko 30 mm diameter by 3 mm thick are folded into quarters.

Packaging and Freezing

Surimi is packed in 10-kg units in both polyethylene bags and in frozen food cartons and frozen in horizontal plate freezers. After freezing, they are packed two blocks per master carton. Surimi should be stored at 0°F or lower since its storage life depends on storage temperatures. For example, the storage life of Alaska pollock surimi at 14°F (−10°C) is about 2 months but at −4°F (−20°C) is about 1 year (Iwata et al., 1971).

DIFFERENT GRADES OF SURIMI

Processors have formed associations that establish quality standards for the various commercial grades of surimi and issue grade certificates for products meeting these standards.

There are three grades for surimi processed at sea and four grades for surimi processed by the shore plants. For example, the four grades for Alaska pollock surimi established by the Hokkaido Surimi Association in 1965 are given in Table 1. The grade of surimi is dependent upon the freshness of the fish used. In addition, the surimi must make a "Kamaboko" that passes the folding test (see Table 1) in order to qualify for a grade certificate. In making the "Kamaboko" for the folding tests, varying amounts of starch are added (see Table 1). These amounts depend upon the potential grade of the surimi, which in turn depends on the freshness of the fish. Also, a higher moisture content for the washed flesh is permitted as the amount of starch used is increased. Other objective quality tests that may be used include measurement for resilience, pH, and whiteness.

U.S. INTEREST IN PRODUCING SURIMI

In view of the continuing high Japanese demand for surimi to be used in "Kamaboko", fish sausage and ham, and the prospects of relaxation of import restrictions by Japan, interest has been expressed by some fisheries groups in the potential of producing surimi in the United States for export. Some of the factors that should be considered by interested groups from the technical aspects of producing surimi have been given in this paper and in the preceding paper on "Kamaboko". Factors for initial consideration are summarized here.

Fish Raw Material

The inherent "Kamaboko"-forming capability (elastic characteristic or gel-forming capacity) of fish muscle proteins varies from species to species as does the rate of loss of this "Kamaboko"-forming capability during iced storage of the fish. For a given species, factors such as freshness of the fish, age and sexual maturity, season, area of catch, etc., may affect its "Kamaboko"-forming capability. Thus, each species must be tested for its suitability. For economical processing, the fish must be available in abundant quantities throughout a long season.

Processing Equipment

Commercial equipment available for surimi production includes flesh separators, washers, dewaterers, and strainers. Heading-and-gutting machines have been designed and are available for such species as Alaska pollock, now used for surimi production. All unwanted soft material (i.e., kidney, bits of viscera, dark membrane lining the visceral cavity) that could be separated from skin and bone together with the fish muscle must be removed before the fish is passed through the flesh separator. For example, the Japanese have developed machines that remove the Alaska pollock's belly flaps, which are lined with a black peritoneum, and the backbone. Similarly, any species suitable for surimi production must lend itself to rapid and economical heading, gutting, and removal of soft extraneous material.

Quality Standards

To produce surimi that meets the quality standards now used by the Japanese surimi manufacturers' association will require close quality control. High standards of sanitation are required throughout the processing plant owing to the opportunity for bacterial contamination of the minced fish muscle during the various processing steps and because final "Kamaboko"-type products have only a limited shelf life. The Japanese have demonstrated that a high quality surimi can be produced by using good manufacturing practices.

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MFR PAPER 1021

Testing the gel-forming capacity of marine fish muscle proteins is part of the technological effort to improve utilization of our fishery resources.

Gel-Forming Capacity of Washed and Unwashed Flesh of Some Pacific Coast Species of Fish

GEORGE KUDO, MINORU OKADA, and DAVID MIYAUCHI

ABSTRACT

Several species of Pacific Ocean fish were tested to determine the gel-forming capacity of their proteins when processed into a heat-pasteurized, finely-comminuted fish product ("Kamaboko"). Lingcod, Pacific cod, rockfish, and some sharks had good gel-forming properties, while flounder, hake, and dogfish did not. Washing the comminuted flesh generally improved the gel-forming properties.

INTRODUCTION

Fish is an excellent food because of the high nutritive value of its muscle protein. In addition to their nutritive value, fish muscle proteins are utilized in processed foods for their functional properties. In Japan, for example, the flesh of certain species of fish is used to make fish sausage (Tanikawa, 1963; Amano, 1965) and the Japanese fish cake called "Kamaboko." The gel-forming capacity of the wet fish protein determines its suitability as raw material for fish sausage and "Kamaboko" as described in the preceding papers.

Some of the species caught off the west coast of the United States were tested to determine the gel-forming capacity of their proteins. Included in these tests were several species not utilized for food in the United States. Testing their muscle proteins for functional properties such as gel-forming capacity is part of our effort to develop the technology for utilizing our fishery resources at the highest level of benefit. This gel-forming capacity was evaluated in terms of elasticity, flexibility, firmness, and cohesiveness of the heat-pasteurized fish gel ("Kamaboko") prepared from the flesh of the various species. Thus, the gel-forming capacity of the fish proteins was measured by the quality of the "Kamaboko" prepared. Since washing the flesh to remove fat and water-soluble substances improves the gel-forming capacity (Okada, 1964), washed flesh of all species was tested as well as the unwashed flesh, which was used as control samples. The results of this study are presented here.

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MATERIALS AND METHODS

Fish Samples

Except for the large sharks, caught off the coast of California, the species used in this study (Table 1) were caught off the coast of Washington. All fish were held in ice while aboard the commercial fishing vessels and during shipment to our laboratory except for the sharks, which were frozen aboard ship and thawed just prior to being used. Two lots each of large-size and small size hake taken from Puget Sound were tested.

Preparation of Comminuted Flesh

At our laboratory, the fish were headed, gutted, washed, and passed through a flesh-separator machine as described by Miyauchi and Steinberg (1970). The tension on the rubber belt was adjusted so that when the headed-and-gutted fish were passed through the machine most of the dark flesh remained with the skin and only the light flesh was recovered from the first pass. The separated minced flesh was weighed to determine the yield. The waste from the first pass was sent through the machine again, and the flesh recovered from this operation was also weighed to obtain yield data. Only the first-pass flesh was used in this study.

About half of the first-pass comminuted flesh from the flesh separator was used directly (unwashed). The other half was washed as follows: One part by weight of comminuted flesh and seven parts by weight of water chilled to 32°F were stirred with a large paddle until thoroughly mixed. The flesh was allowed to settle for about 10 minutes; the supernatant containing fat, blood, and water-soluble proteins and minerals was decanted. Washing was repeated four more times. The fifth washing was made with a chilled 0.15 percent salt solution to

Table 1.—Species of fish tested for gel-forming capacity.

Common name	Scientific name	Month caught	Days on ice	Number of fish	Total weight (lb)
Cod, Pacific (true cod)	*Gadus macrocephalus*	Dec.	1	20	130
Dogfish, Spiny	*Squalus acanthias*	Nov.	1	7	32
Flounder, Starry	*Platichthys stellatus*	Oct.	1	58	147
Hake, Pacific (Puget Sound)	*Merluccius productus*				
Lot 1		March	1	35	26
Lot 2		May	1	150	112
Lot 3		Nov.	1	18	39
Lot 4		Jan.	2	24	53
Lingcod	*Ophiodon elongatus*				
Lot 1		Aug.	1	9	51
Lot 2		Sept.	4	3	35
Lot 3		Oct.	4	2	11
Ratfish	*Hydrolagus colliei*	Dec.	1	7	32
Rockfish					
Black	*Sebastes melanops*	Aug.	1	2	7
Bocaccio	*Sebastes paucispinis*	Sept.	5	5	35
Canary	*Sebastes pinniger*	July	3	11	57
Flag	*Sebastes rubrivinctus*	July	4	11	57
Pacific ocean perch	*Sebastes alutus*	Sept.	2	12	24
Silvergray	*Sebastes brevispinis*	Oct.	4	7	44
Sharks					
Blue	*Prionace glauca*	Sept.	F[1]	1	—
Hammerhead, scalloped	*Sphyrna lewini*	Nov.	F	1	—
Whitetip	*Carcharhinus longimanus*	Dec.	F	1	—

[1] Frozen

facilitate the removal of water from the flesh. The mixture was decanted onto cheesecloth to recover the flesh, which was then placed in a hydraulic press, and pressed at up to 20 pounds per square inch for 10 minutes to remove the remaining wash water.

Heat-Pasteurized Fish Gel Preparation

Salt, sugar, and tripolyphosphate were added to both the washed and unwashed flesh at levels of 2.5 percent, 5 percent, and 0.2 percent (W/W), respectively. The mixture was ground for 20 minutes in a prechilled, powered stone mortar operated in a 34°F chilled room in order to minimize the temperature rise of the flesh during grinding. The resulting ground paste was stuffed into polyvinylidene chloride sausage casing 3 cm in diameter. This was heat-pasteurized in a water bath at 180°F for 40 minutes.

Determination of Gel-Forming Capacity

The gel-forming capacity was determined on the "Kamaboko" in terms of flexibility and elasticity by the folding test and on texture by sensory test.

The folding test was made by folding in half a slice of the "Kamaboko" product 3 mm thick by 3 cm in diameter. If no cracking occurred along the fold, the slice was folded again perpendicular to the first fold. The 5-point rating scale of the folding test was based on the grades that were defined by Nishiya (1963) as follows:

Numerical score	Nishiya's grade	Results of folding	Degree of elasticity
5	AA	No cracks on folding into quarters	Extremely elastic
4	A	No cracks on folding in half; cracks on folding into quarters	Moderately elastic
3	B	Some cracking on folding in half	Slightly elastic
2	C	Breaks into pieces on folding in half	Not elastic
1	D	Breaks into fragments with finger pressure	Poor

Texture by Sensory test

The texture of the heat-pasteurized fish gel with respect to its cohesiveness, firmness, and moistness was determined on a slice 2 cm thick by 3 cm in diameter. The texture was rated on the following 10-point scale: 9-10, Excellent; 7-8, Good; 5-6, Standard; 3-4, Substandard; 1-2, Poor.

Expressible Water

Expressible water to measure water-holding capacity was determined as follows: A slice of "Kamaboko" 1 cm in diameter by 0.3 cm thick pressed between four sheets of Whatman No. 1 filter paper (two on each side) for 1 minute under a weight of 8.8 kg. The percent expressible water was based on the difference in weight of the "Kamaboko" before and after pressing.

Determination of Moisture Content

The moisture content of the "Kamaboko" was measured by the rapid moisture determination balance (Ohaus scale. Model 6010)[1] equipped with an infrared lamp. Ten grams of finely chopped "Kamaboko" were spread thin on a flat aluminum dish and placed under the lamp for 25 minutes or until a constant weight was obtained.

RESULTS

Minced Flesh Yield

The minced flesh yields for the first pass and second pass through the flesh separator for the various species are given in Table 2. The difference in the flesh yield between the first and second passes is dependent upon the arbitrary adjustment of the tension exerted by the belt. Somewhat higher or lower yields could be obtained by different adjustments of the tensions. In addition

[1] Use of trade names in this publication does not imply endorsement of commercial products by the National Marine Fisheries Service.

to the flesh yield, those of head and viscera and of skin and bones are given in Table 2.

Gel-Forming Capacity Discussed by Species

Lingcod

Both the washed and unwashed flesh of iced lingcod have good gel-forming capacity for as long as 10 days (Table 3). The "Kamaboko" made from both types of flesh had good color, flavor, and extremely good elasticity and flexibility. Since the gel-forming capacity is not affected by holding the lingcod in iced storage, it is an excellent species for making "Kamaboko" and fish sausage.

Pacific Cod

The unwashed flesh of 1-day iced cod made "Kamaboko" having extremely good elasticity but only average overall texture. "Kamaboko" made from unwashed 5-day iced fish was crumbly and poor in overall quality. On the other hand, the gel-forming capacity of washed flesh was good. The washed flesh of cod iced for 1 day made "Kamaboko" having extremely good flavor, elasticity, and flexibility as determined by the sensory and folding tests (Table 4). The gel-forming capacity of cod decreased with time of iced storage, but the "Kamaboko" made from washed flesh of cod iced for as long as 9 days had good elasticity and flexibility and a slightly higher water-holding capacity than that made from the unwashed flesh. In summary, the gel-forming capacity of washed minced flesh of Pacific cod is good even after 9 days in ice. The gel-forming capacity of washed flesh is better than that of unwashed flesh.

Rockfish

Based on the six species tested (Table 5), rockfish has good gel-forming

Table 2.—Yield of flesh and waste (based on weight of whole fish) from some Pacific Ocean fish passed through a laboratory-model flesh separator.

Species	Weight of fish used	Yield of flesh: 1st pass	Yield of flesh: 2nd pass	Yield of flesh: Total	Yield of waste: Head and viscera	Yield of waste: Skin and bones	Yield of waste: Total
	Kg	Percent					
Cod, Pacific	17.4	32.5	5.3	37.8	45.5	16.7	62.2
Dogfish, Spiny	14.5	20.9	16.0	36.9	52.1	11.0	63.1
Flounder, Starry	67.0	27.1	15.8	42.9	46.0	11.1	57.1
Hake, Pacific (Puget Sound)							
Lot 1	11.8	39.0	—	—	45.0	—	—
Lot 2	50.8	41.0	—	—	52.0	—	—
Lot 3	17.7	33.0	16.0	49.0	44.6	6.4	51.0
Lot 4	24.1	37.0	—	—	50.0	—	—
Lingcod							
Lot 1	25.2	41.0	6.9	47.9	40.0	12.1	52.1
Lot 2	15.9	39.0	12 0	51.0	38.0	11.0	49.0
Lot 3	5.1	46.5	11.4	57.9	33.0	9.1	42.1
Rockfish							
Black	33.2	32.4	14.4	46.8	42.7	10.5	53.2
Bocaccio	15.9	27.0	17.7	44.7	43.0	12.3	55.3
Canary	25.9	29.5	11.3	40.8	46.0	13.2	59.2
Flag	25.8	28.0	—	—	49.0	12.6	61.6
Pacific ocean perch	10.9	29.0	10.2	39.2	44.0	16.8	60.8
Silvergray	19.9	35.8	10.7	46.5	42.3	11.2	53.5

Table 3.—Gel-forming capacity of washed and unwashed flesh of lingcod held in ice for varying periods.

Lot	Fish stored in ice	Properties of "Kamaboko" made from: Washed flesh: Texture by sensory test	Washed flesh: Elasticity by folding test	Washed flesh: Moisture content	Unwashed flesh: Texture by sensory test	Unwashed flesh: Elasticity by folding test	Unwashed flesh: Moisture content
Number	*Days*	*10-pt scale*	*5-pt scale*	*Percent*	*10-pt scale*	*5-pt scale*	*Percent*
1	1	9	5	76.5	8	5	72.9
	6	10	5	75.4	8	5	72.9
2	4	8	5	77.3	7	5	73.3
	10	9	5	77.0	7	5	73.2
3	4	7.5	5	79.5	9	5	72.0
	10	9	5	76.8	8	5	74.4

Table 4.—Gel-forming capacity of washed and unwashed flesh of Pacific cod iced for varying periods.

Treatment of flesh	Fish stored in ice	Properties of "Kamaboko": Texture by sensory test	Elasticity by folding test	Expressible water	Moisture content
	Days	*10-pt scale*	*5-pt scale*	*Percent*	*Percent*
Washed	1	9	5	12.8	79.0
	5	6.5	5	11.9	78.1
	9	7.5	5	9.7	76.5
Unwashed	1	6	5	29.5	81.0
	5	3	2	31.7	77.7

capacity and appears to be a good source of raw material for making "Kamaboko"-type products. The unwashed flesh of five species made standard- to good-grade "Kamaboko" having good elasticity, reasonably good flexibility, a light tan to off-white color, and good flavor. The unwashed flesh of only the silvergray rockfish made a soft, substandard-grade "Kamaboko."

The "Kamaboko" made from the washed flesh of all six species were better in quality than those made from the unwashed flesh. Washing the flesh improved the color, flavor, and flexibility of the "Kamaboko."

Holding Pacific ocean perch for as long as 8 days in ice had no effect on its gel-forming characteristics. There was no significant change in color, flavor, elasticity, or flexibility of the "Kamaboko" owing to the storage of fish in ice.

Starry Flounder

The washed flesh of 1-day iced starry flounder had good gel-forming capacity and made "Kamaboko" having good elasticity and excellent flexibility (Table 6). The washed flesh of 6-day iced fish made standard-grade "Kamaboko" having excellent flexibility, but that of 12-day iced fish lost much of its gel-forming capacity and made substandard-grade "Kamaboko" having slight elasticity and flexibility. Thus, the washed flesh of starry flounder iced for as long as 6 days has good gel-forming capacity suitable for making "Kamaboko" and fish sausage. The unwashed flesh of starry flounder, on the other hand, had poor gel-forming capacity even for fish iced 1 day.

Puget Sound Hake

The results of the tests to determine the gel-forming capacity of two lots of large hake and of two lots of small hake are given in Tables 7 and 8, respectively.

Large hake. — The washed flesh of 1-day iced, large-size hake had low gel-forming capacity and made "Kamaboko" having soft-to-mushy texture. However, the gel-forming capacity of the washed flesh of large hake iced for either 5, 7, or 10 days was much better, and the washed flesh made average-grade "Kamaboko" having good elasticity. In comparison, the unwashed flesh had low gel-forming capacity and made a mushy-textured "Kamaboko."

It is difficult to explain why these large-size hake that were iced for longer periods produced better "Kamaboko" than the fresher fish. Although it was difficult to dewater the washed flesh of 1-day iced fish and easier to dewater washed flesh of fish iced for longer periods, there was no clearcut relation between this phenomenon and the amount of expressible water and moisture content of the "Kamaboko" produced. Furthermore, no proteolytic enzymic activity was found in the 1-day iced hake that produced a poor "Kamaboko," and only a small amount of activity was detected in the 10-day iced hake that made an elastic standard-grade "Kamaboko."

Small hake. — For the small-size Puget Sound hake, the washed flesh of the fish caught in March, irrespective of whether they were iced for only 1

Table 5.—Gel-forming capacity of washed and unwashed flesh of rockfish held in ice for varying periods.

		Properties of "Kamaboko" made from:					
		Washed flesh			Unwashed flesh		
Species of rockfish	Fish stored in ice	Texture by sensory test	Elasticity by folding test	Moisture content	Texture by sensory test	Elasticity by folding test	Moisture content
	Days	*10-pt scale*	*5-pt scale*	*Percent*	*10-pt scale*	*5-pt scale*	*Percent*
Black	1	8	5	84	6	4	84
Bocaccio	5	9	5	73.0	7	5	71.2
Canary	3	8	5	75	6.5	5	72
Flag	4	9	5	77	8	5	73
Pacific ocean perch	2	9	5	77.3	8	5	67.7
	5	9.5	5	76.4	8	5	71.0
	8	9	5	76.7	8	5	70.5
Silvergray	4	7.5	5	76.8	3	2	72.7

Table 6.—Gel-forming capacity of washed and unwashed flesh of starry flounder iced for varying periods.

		Properties of "Kamaboko"			
Treatment of of flesh	Fish stored in ice	Texture by sensory test	Elasticity by folding test	Expressible water	Moisture content
	Days	*10-pt scale*	*5-pt scale*	*Percent*	*Percent*
Washed	1	7	5	17.5	78.0
	6	5	5	19.6	76.1
	12	4	3	21.6	77.3
Unwashed	1	4	3.5	33.8	76.0
	6	3	3.5	37.3	76.5
	12	2	2	39.6	78.6

Table 7.—Gel-forming capacity of washed and unwashed flesh of large (50 to 60 cm) Puget Sound hake iced for varying periods.

Month caught	Treatment of flesh	Fish stored in ice	Texture by sensory test	Elasticity by folding test	Expressible water	Moisture content
			Properties of "Kamboko"			
		Days	*10-pt scale*	*5-pt scale*	*Percent*	*Percent*
November	Washed	1	2	2	[1]	78.5
		5	7	5	13.2	77.5
	Unwashed	1	1	1	[1]	79.6
		5	2	2	[1]	79.4
January	Washed	1	4	3	14.0	81.3
		7	7	5	6.4	79.1
		10	6	—	5.5	76.5

[1] Too mushy to determine expressible water.

day or as long as 9 days, made standard-grade elastic "Kamaboko" (Table 8). At each sampling date, fish that were obviously parasitized were segregated and tested separately. Parasitized fish made a slightly less elastic "Kamaboko" than the parasite-free fish; the sensory scores were lower for the "Kamaboko" prepared from the fish with parasites. The protozoan parasites in Puget Sound hake appear to have proteolytic enzyme of relatively low activity and therefore do not adversely affect the "Kamaboko"-forming capacity of parasitized fish. The unwashed flesh of the small hake had low gel-forming capacity and made a mushy-textured "Kamaboko" similar to the unwashed flesh of the large hake.

The results of the washed flesh of the second lot of small hake, which was more limited in scope, were similar to those of the first lot.

Dogfish

One-day iced dogfish had low gel-forming capacity and made poor-grade "Kamaboko" (Table 9). "Kamaboko" made with unwashed flesh was mushy, and that made with washed flesh was crumbly in texture. On the other hand, five-day iced dogfish made a better grade "Kamaboko". The unwashed flesh made a standard-grade "Kamaboko" that was moderately elastic, but the washed flesh made a substandard "Kamaboko" having slight elasticity. Although there were differences in the moisture contents of the "Kamaboko" made from 1-day iced and 5-day iced dogfish (Table 9), their effect on the quality of the "Kamaboko" is not known. A systematic study with respect to effect of size of dogfish, season of catch, iced storage, etc., on the gel-forming capacity of dogfish flesh is needed.

Pelagic Sharks

Blue shark, scalloped hammerhead shark, and whitetip shark, in spite of being frozen and stored at $-5\,^{\circ}C$ ($23\,^{\circ}F$) for about 1 month, had good gel-forming capacity and made a very elastic "Kamaboko" (Table 10). The unwashed flesh of the hammerhead and whitetip sharks made good-to-excellent grade "Kamaboko" with excellent elasticity and flexibility, but the unwashed flesh of blue shark produced a very unusual soft and spongy-textured "Kamaboko." The washed flesh of blue shark, however, made an excellent-grade "Kamaboko" with good elasticity and flexibility.

DISCUSSION

After washing and dewatering by pressing, the moisture content of the washed flesh should be brought back to the approximate level of the flesh prior to washing. In practice, the moisture content of the dewatered flesh was usually in the range of 75-85 percent. Difficulty in dewatering the washed flesh was often encountered when the fish was too fresh. Since the moisture content of the washed flesh could not be precisely controlled, the moisture content of the "Kamaboko" produced was determined. Although the moisture content of the

Table 8.—Gel-forming capacity of washed and unwashed flesh of small (20 to 30 cm) Puget Sound hake iced for varying periods.

Month caught	Treatment of flesh	Fish stored in ice	Texture by sensory test	Elasticity by folding test	Expressible water	Moisture content
			Properties of "Kamaboko"			
		Days	*10-pt scale*	*5-pt scale*	*Percent*	*Percent*
March	Washed, normal flesh	1	6.5	5	9.3	83.6
		2	6.5	5	8.3	81.1
		6	6.5	5	5.8	78.0
		9	6.0	5	6.4	77.6
	Washed (parasitized flesh)	1	5.5	5	9.5	79.3
		2	5.0	4.5	10.5	78.3
		6	5.5	5	4.8	74.5
		9	4.5	5	11.1	79.6
	Unwashed	1	1.5	1	31.0	79.1
		2	1.5	1	24.5	79.6
		6	2.0	2	26.5	79.9
May	Washed	1	6.5	5	14.7	78.9
		3	7.5	5	12.8	78.1

Table 9.—Gel-forming capacity of washed and unwashed spiny dogfish iced for 1 and 5 days.

	Properties of "Kamaboko" made from:					
	Washed flesh			Unwashed flesh		
Fish stored in ice	Texture by sensory test	Elasticity by folding test	Moisture content	Texture by sensory test	Elasticity by folding test	Moisture content
Days	*10-pt scale*	*5-pt scale*	*Percent*	*10-pt scale*	*5-pt scale*	*Percent*
1	2	2	72.4	1	2	70.9
5	5	4	67.0	3	3	65.2

Table 10.—Gel-forming capacity of washed and unwashed flesh of blue shark, scalloped hammerhead shark, and oceanic whitetip shark.

	Properties of "Kamaboko" made from:					
	Washed flesh			Unwashed flesh		
Species of shark	Texture by sensory test	Elasticity by folding test	Moisture content	Texture by sensory test	Elasticity by folding test	Moisture content
	10-pt scale	*5-pt scale*	*Percent*	*10-pt scale*	*5-pt scale*	*Percent*
Blue	9	5	73.9	6	5	82.7
Hammerhead, scalloped	8	5	77.0	9.5	5	77.5
Whitetip, oceanic	9	5	72.9	8	5	79.9

"Kamaboko" did vary, there appeared to be no correlation between it and the objective tests used to measure gel-forming capacity of the various samples.

With lingcod, rockfish, hake, and other species that appear to have good gel-forming capacity, systematic studies should be made of the gel-forming capacity in relation to freshness, age or size of fish, the time of year landed and spawning condition, the fishing ground, and the incidence of parasites.

SUMMARY

Preliminary screening of some species of the Pacific Coast for gel-forming capacity was made. The yield of flesh recovered from the first and second passes through the flesh separator ranged from 36.9 percent for spiny dogfish to 57.9 percent for lingcod.

Washing the comminuted flesh with chilled water to remove some of the water-soluble proteins was very effective in improving the gel-forming capacity. Washing also removed blood, fat, small pieces of skin, and any "fishy" odors.

The species studied might be conveniently divided into three groups with regard to stability in gel-forming capacity during ice storage:

1. Lingcod, Pacific cod, Pacific ocean perch produced good- to excellent-grade "Kamaboko" even after 8 to 10 days of iced storage when washed flesh was used. The washed flesh of other rockfish (black, bocaccio, canary, and flag) also produced good- to excellent-grade "Kamaboko."
2. Silvergray rockfish, starry flounder, and hake produced standard- to good-grade "Kamaboko" from washed flesh of fish iced for up to seven days.
3. Dogfish produced substandard- to poor-grade "Kamaboko" from washed flesh.

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MFR PAPER 1022

New study establishes values of chemical constituents of 32 types of fish.

Chemical and Nutritive Values of Several Fresh and Canned Finfish, Crustaceans, and Mollusks Part I: Proximate Composition, Calcium, and Phosphorus

VIRGINIA D. SIDWELL, JAMES C. BONNET, and ELIZABETH G. ZOOK

ABSTRACT

This paper presents the proximate composition, calcium, and phosphorus of the edible portion of 32 commonly eaten finfish, crustaceans and mollusks. Among these are the canned finfish, salmon and tuna in oil and tuna in brine. The mean, standard error of the mean, range, and number of analyses are given for each component.

INTRODUCTION

The data found in literature generally cover the results of a very limited number of chemical or nutritive components in several species of fish or fishery products. It is rare to find the results of as many analyses as we are reporting on the same species of fish or fishery product. Consequently these results are unique. The data are divided into three parts. (1) the proximate composition, calcium, and phosphorus; (2) crude fat and fatty acid composition; and (3) the amino acid composition. Part I on proximate composition is complete for the number of samples tested. The other two, which will appear later, are interim reports. The demand for these data has been so great that the partially complete listings will be valuable in giving a good approximation of the fatty acid content and amino acid content of raw edible fish or fishery products.

The objective of this paper (Part I) is to report the mean, standard error of the mean, range, and number of analyses for moisture, crude protein, ether fat,[1] ash, calcium, and phosphorus content of 32 commonly eaten fish or fishery products.

PROCEDURE

Samples

Samples were collected by personnel in the Technology Laboratories at Gloucester, Mass.; Pascagoula, Miss.; Seattle, Wash.; and College Park, Md. Each laboratory was assigned species of fish to be collected, as shown in Table 1.

Sampling Plan

The fish used in the study are the same as the ones used for the microconstituent study (Zook et al., Ms.) conducted by the College Park Laboratory.

[1] Ether fat or crude fat is that portion of a moisture-free fish sample that can be extracted by ethyl ether or petroleum ether.

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The collectors at each of the laboratories were requested to obtain eight samples of each of their assigned species large enough to be divided into two subsamples. Regrettably this was not adhered to in some cases, so the College Park technologists did not have sufficient samples for the following seven species: cultivated and wild catfish, *Icatalurus punctatus;* spiny lobster, *Panulirus argus;* calico scallops, *Argopecten gibbus;* Gulf white shrimp and South Atlantic white shrimp, *Penaeus setiferus;* and red snapper, *Lutjanus campechanus.* The remaining species contain data on nine individual lots with the 10th sample being a within-species duplication. The samples were caught during the spring, summer, and fall of 1971.

The information on the location of catch, date of catch, number of fish in each sample, and name of the boat and captain or the name of the com-

Table 1.—Species of fish to be obtained by each Technology Laboratory of the National Marine Fisheries Service.

Gloucester, Mass.	Pascagoula, Miss.	Seattle, Wash.	College Park, Md.
Cod inshore	Catfish cultured wild	Crab, king body meat leg meat	Clam hard shell soft shell surf
Flounder yellowtail	Lobster spiny	Halibut Pacific	Cod Icelandic
Haddock inshore	Scallop calico	Rockfish California	Crab blue
Oyster Long Island	Shrimp brown white, Gulf white, So. Atl.	Salmon sockeye canned	Hake Pacific
Perch ocean	Snapper red	Shrimp Alaskan Asian Mexican	Oyster Md. & Va.
Pollock Atlantic		Tuna yellowfin (canned)	
Scallop bay sea			
Shrimp Maine			
Whiting domestic			

Table 2.—Proximate composition, calcium, and phosphorus content of the edible portions of raw finfish.

Fresh finfish	Proximates				Minerals	
	Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Ca mg%	P mg%
Catfish (Cultured)	[1]77.4 ± 0.1	20.5 ± 0.7	1.53 ± 0.09	0.65 ± 0.32	64 ± 8	228 ± 14
Ictalurus punctatus	[2]74.5—80.7	17.0—23.9	1.10—1.94	0.09—2.31	20—90	130 – 240
	[3]10	10	10	8	9	9
Catfish (Wild)	79.4 ± 0.2	18.2 ± 0.3	1.19 ± 0.02	0.96 ± 0.11	27 ± 2	214 ± 8
Ictalurus punctatus	77.9—80.0	16.3—19.7	1.09—1.25	0.51—1.51	19—37	158—298
	10	10	10	9	9	15
Cod (Icelandic)	81.4 ± 0.2	18.1 ± 0.2	1.20 ± 0.02	0.10 ± 0.02	22 ± 1	192 ± 7
Gadus morhua	79.0—83.1	16.7—19.6	1.01—1.36	0.01—0.26	18—30	150—240
	22	20	20	20	16	15
Cod (Inshore-Domestic)	80.1 ± 0.3	19.6 ± 0.3	1.26 ± 0.04	0.12 ± 0.02	42 ± 5	222 ± 6
Gadus morhua	76.8—83.3	16.3—21.8	0.96—1.84	0.00—0.30	19—80	180—270
	23	24	20	20	16	18
Flounder, Yellowtail	76.5 ± 0.3	22.3 ± 0.4	1.21 ± 0.04	0.37 ± 0.06	27 ± 2	203 ± 12
Limanda ferruginea	74.1—78.7	18.8—25.5	1.05—1.76	0.05—1.16	20—40	170—300
	20	20	20	19	14	12
Haddock (Inshore)	79.0 ± 0.2	20.4 ± 0.3	1.50 ± 0.05	0.11 ± 0.01	62 ± 7	211 ± 13
Melanogrammus aeglefinus	78.0—80.7	16.7—22.6	1.12—1.87	0.03—0.23	20—90	150—350
	20	20	21	20	11	20
Hake, Pacific	80.1 ± 0.2	18.4 ± 0.4	1.25 ± 0.04	0.69 ± 0.10	28 ± 3	176 ± 5
Merluccius productus	78.7—81.1	16.2—22.4	1.00—1.59	0.20—1.50	20—50	150—200
	18	18	18	17	17	15
Halibut, Pacific	77.5 ± 0.4	20.1 ± 0.3	1.27 ± 0.02	1.22 ± 0.23	47 ± 6	221 ± 8
Hippoglossus stenolepsis	76.6—80.9	18.1—22.9	1.14—1.49	0.43—3.90	20—78	160—260
	23	21	21	19	13	16
Perch, Ocean	77.3 ± 0.3	21.7 ± 0.3	1.45 ± 0.03	0.81 ± 0.11	141 ± 7	223 ± 6
Sebastes marinus	75.8—80.2	19.6—24.8	1.18—1.71	0.10—1.44	80—190	160—270
	21	19	22	17	21	23
Pollock	77.7 ± 0.2	20.9 ± 0.2	1.47 ± 0.06	0.15 ± 0.03	87 ± 12	228 ± 10
Pollachius virens	75.8—80.6	19.2—22.5	1.12—2.01	0.0—0.51	30—150	160—300
	22	23	20	20	11	16
Rockfish, Pacific	79.7 ± 0.2	19.8 ± 0.3	1.26 ± 0.03	0.53 ± 0.10	39 ± 5	214 ± 7
Sebastes sp.	78.0—81.3	18.0—22.6	1.07—1.42	0.03—1.58	20—90	160—250
	22	22	20	19	9	12
Snapper, Red	76.0 ± 0.2	22.4 ± 0.1	1.31 ± 0.02	0.41 ± 0.08	28 ± 4	210 ± 8
Lutjanus blackfordii	73.8—77.7	20.9—23.6	1.16—1.55	0.09—1.36	20—50	160—240
	24	23	20	21	15	19
Whiting	78.7 ± 0.4	17.8 ± 0.2	1.26 ± 0.03	2.43 ± 0.22	72 ± 6	222 ± 11
Merluccius bilinearis	75.6—80.9	16.3—19.5	1.00—1.53	0.78—4.76	50—100	150—290
	22	25	21	20	11	13

[1] Mean and standard error of the mean.
[2] Range.
[3] Number of analyses.

mercial supplier may be obtained from the Appendix of Zook et al. (Ms.).

Sample Preparations

Fish were filleted and skinned if possible. The fillets were very finely ground in either a stainless steel Hobart[2] Silent Cutter or Waring Blendor. With the canned fish the entire contents of each can were ground. The flesh of mollusks and crustaceans was removed from the shell and treated like the finfish. All equipment was rinsed with double distilled water just prior to use. The finely ground fish was packed into 4-ounce plastic ice cream containers, packed in dry ice, and shipped via air freight to College Park.

[2] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

ANALYTICAL PROCEDURES

The analyses for crude protein and ether fat were done according to the methods described in the Official Methods of Analysis (Horwitz, 1970: protein 2-051; ether fat, 7.048).

The moisture analyses were done by placing a weighed sample in moisture tins, dried for 16 hours in a forced air oven at 100°C.

The ash was determined by placing the sample in a crucible and burning it at 550°C for 16 hours.

The calcium and phosphorus were determined by an automated method outlined in the paper by Smith, Kurtzman, and Ambrose (1966).

Table 3.—Proximate composition, calcium, and phosphorus content of the edible portions of canned finfish.

Canned finfish	Proximates: Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Minerals: Ca mg%	P mg%
Salmon, Sockeye	[1]71.3 ± 0.2	21.0 ± 0.2	2.35 ± 0.11	6.04 ± 0.13	22 ± 1	273 ± 10
Oncorhynchus nerka	[2]69.3—72.5	19.3—22.1	1.55—3.03	5.20—7.08	19—28	180—340
	[3]16	20	17	16	9	17
Tuna, Yellowfin (canned	59.9 ± 0.4	22.9 ± 0.5	1.91 ± 0.05	15.2 ± 0.4	37 ± 7	224 ± 5
in oil)	57.9—62.2	19.3—24.3	1.51—2.11	13.0—17.7	20—67	190—260
Thunnus albacares	14	12	12	11	7	15
Tuna, Yellowfin (canned	74.8 ± 0.4	24.0 ± 0.2	1.48 ± 0.12	0.81 ± 0.08	33 ± 9	195 ± 12
in brine)	73.1—76.5	23.3—24.8	1.14—1.92	0.43—1.04	20—50	180—230
Thunnus albacares	8	8	8	8	3	4

[1] Mean and standard error of the mean.
[2] Range.
[3] Number of analyses.

Table 4.—Proximate composition, calcium, and phosphorus content of the edible portion of raw crustaceans.

Crustaceans	Proximates: Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Minerals: Ca mg%	P mg%
Crab, Blue	[1]77.4 ± 0.3	19.8 ± 0.1	2.06 ± 0.04	1.02 ± 0.07	102 ± 12	272 ± 10
Callinectes sapidus	[2]75.2—80.6	18.4—21.0	1.81—2.46	0.55—1.58	22—180	200—370
	[3]22	22	22	20	13	16
Crab, King (body)	79.2 ± 0.3	18.3 ± 0.2	1.60 ± 0.05	0.38 ± 0.02	42 ± 3	212 ± 10
Paralithodes camschatica	76.7—81.4	17.0—19.5	1.19—1.83	0.24—0.54	21—69	180—273
	16	16	16	16	24	25
Crab, King (leg)	76.8 ± 0.07	20.1 ± 0.5	1.81 ± 0.06	0.40 ± 0.03	55 ± 4	228 ± 10
Paralithodes camschatica	69.2—79.3	17.2—24.9	1.28—2.52	0.22 – 0.67	40—80	160—320
	17	18	18	18	12	18
Lobster, Spiny	75.6 ± 0.3	23.1 ± 0.2	1.71 ± 0.02	0.33 ± 0.03	47 ± 4	237 ± 11
Panulirus argus	74.2—79.0	22.0—25.6	1.51—1.96	0.17—0.55	20—80	150—320
	23	20	20	15	18	19
Shrimp, Alaskan	77.4 ± 0.3	20.1 ± 0.4	2.26 ± 0.14	0.64 ± 0.02	49 ± 4	187 ± 4
Mixed spp.	75.5—79.7	16.7—26.2	1.41—3.77	0.44—0.85	40—80	170—210
	20	22	19	20	14	12
Shrimp, Asian	84.0 ± 0.4	15.2 ± 0.4	0.77 ± 0.03	0.42 ± 0.17	68 ± 5	181 ± 10
Mixed spp.	81.0—87.3	13.1—18.8	0.53—0.96	0.12 – 3.00	30—90	130—230
	20	20	21	16	14	10
Shrimp, Brown	76.2 ± 0.1	21.4 ± 0.2	1.63 ± 0.01	0.14 ± 0.01	59 ± 2	248 ± 5
Penaeus aztecus	75.2—76.5	17.2—23.3	1.54—1.72	0.05—0.28	40—80	220—290
	20	23	20	20	19	18
Shrimp, Maine	81.5 ± 0.5	17.1 ± 0.4	1.30 ± 0.06	0.39 ± 0.05	54 ± 4	177 ± 9
Pandalus borealis	77.9—86.0	13.5—20.2	0.93—1.86	0.12—0.82	40—80	150—270
	19	23	20	19	11	14
Shrimp, Mexican	80.4 ± 0.3	18.1 ± 0.3	1.40 ± 0.04	0.18 ± 0.03	95 ± 2	176 ± 4
Mixed spp.	78.5—82.5	16.5—20.6	1.14—1.68	0.06—0.55	70—120	150—210
	22	23	20	18	14	18
Shrimp, White (Gulf)	77.4 ± 0.2	20.6 ± 0.1	1.41 ± 0.02	0.20 ± 0.02	50 ± 1	233 ± 9
Penaeus setiferus	76.4—78.7	19.5—21.6	1.26—1.57	0.05—0.40	40—60	150—290
	20	21	20	20	20	17
Shrimp, White	76.2 ± 0.2	22.0 ± 0.2	1.90 ± 0.05	0.17 ± 0.02	64 ± 3	281 ± 11
(South Atlantic)	75.3—79.5	20.9—23.5	1.86—2.03	0.06—0.26	50—90	160—350
Penaeus setiferus	22	20	20	15	17	17

[1] Mean and standard error of the mean.
[2] Range.
[3] Number of analyses.

RESULTS AND DISCUSSIONS

The proximate composition of the raw edible portion of finfish is listed in Table 2. The standard error of the mean for each mean value is quite small. The ranges for each species are quite large. This variability may be due to the fact that these fish may have been in different physiological status since they were caught from spring to fall. These finfish may be considered as low-fat fish since the range of fat in the fish flesh was from 0.00 to 4.76 percent.

Table 5.—Proximate composition, calcium, and phosphorus content of the edible portion of raw Mollusca.

Mollusca	Proximates: Moisture g%	Crude protein g%	Ash g%	Ether fat g%	Minerals: Ca mg%	P mg%
Clams (Hard Shell)	[1]91.8±0.1	4.41±0.17	1.97±0.02	0.21±0.02	65±3	69±3
Marcenaria mercenaria	[2]90.8—92.5	3.20—6.24	1.79—2.16	0.10—0.42	20—91	50—130
	[3]20	19	20	20	31	26
Clams (Soft Shell)	83.3±0.9	9.51±0.43	1.19±0.09	1.27±0.16	53±3	152±6
Mya arenaria	76.6—90.8	5.48—11.68	0.62—1.99	0.42—2.64	17—73	110—206
	20	20	17	20	27	24
Clams (Surf)	79.4±0.2	15.6±0.1	2.29±0.10	0.34±0.06	41±3	194±5
Spisula solidissima	78.2—80.9	14.6—16.7	1.10—3.05	0.10—0.87	17—80	110—265
	20	20	20	20	31	36
Oysters (Long Island)	85.4±0.2	7.86±0.23	1.11±0.02	1.13±0.07	52±3	145±6
Crassostrea virginica	82.5—86.6	6.65—10.28	0.93—1.28	0.75—1.89	30—70	110—240
	20	20	20	20	20	20
Oysters (Maryland & Virginia)	88.3±0.2	5.77±0.24	0.65±0.02	1.06±0.08	36±4	121±5
	87.0—90.0	4.48—7.86	0.55—0.83	0.56—1.97	20—70	100—140
Crassostrea virginica	21	20	20	19	17	7
Scallops (Bay)	78.8±0.7	14.1±0.1	1.42±0.02	0.20±0.03	32±5	207±5
Pecten sp.	76.4—87.8	12.9—14.8	1.25—1.59	0.09—0.43	20—80	180—250
	20	19	20	20	16	17
Scallops (Calico)	77.8±0.4	16.9±0.1	1.79±0.01	0.21±0.02	32±2	215±5
Argopecten gibbus	76.8—83.6	15.9—18.5	1.71—1.89	0.11—0.31	20—60	160—270
	20	20	20	19	19	20
Scallops (Sea)	78.2±0.2	18.2±0.1	1.50±0.02	0.17±0.02	22±1	234±16
Placopecten magellanicus	77.2—79.7	17.1—19.0	1.38—1.84	0.02—0.32	20—30	150—320
	21	20	20	20	15	16

[1] Mean and standard error of the mean.
[2] Range.
[3] Number of analyses.

There was a great variability in the amounts of calcium and phosphorus found in the raw flesh. Probably this is due to the method of filleting the fish. It is rather difficult to remove all the bony tissue during the fillet process, and smaller fish would retain more bones.

In Table 3 are the results of the most commonly utilized canned finfish. The fat content of the canned in oil tuna is 5 percent lower than the value listed in Agriculture Handbook 8 (Watt and Merrill, 1963: 15.2 and 20.5, respectively). The same is true for the protein value. The fat content of the tuna canned in brine is the same, 0.8 percent, but the protein value is lower in our results—24.0 percent and 28.0 percent, respectively. The canned salmon is approximately like the ones found in Handbook 8.

In Table 4 it may be observed that the king crab, *Paralithodes camschatica*, tends to have a higher protein value in the leg portion than in the body meat. The tail meat of the spiny Florida lobster, *Panulirus argus*, has the highest protein value. The fat content of the crustaceans is very low except for the blue crab, *Callinectes sapidus*.

As it may be noted in Table 5, some oysters contain much less protein and more moisture than the scallops. The scallops approximate the values observed in finfish or crustaceans.

In summary, this report presents values for crude protein, moisture, ether fat, ash, calcium, and phosphorus of 32 fish or fishery products that are commonly eaten in the United States.

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MFR PAPER 1023

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While the world squid catch octupled between 1938 and 1968, the resource potential is still enormous.

Northwest Atlantic Squids

WARREN F. RATHJEN

In 1938 the world catch of squids amounted to about 115 thousand metric tons. Thirty years later (1968) this figure had increased to approximately 900 thousand tons, most of which was harvested by the Japanese and utilized in various oriental and southern European markets. In addition to squids, there are harvested large amounts of other cephalopods. Octopus and cuttlefish are taken for food. If one adds to this estimates of squids and related animals, incredibly large resources are indicated. Indeed, squids are so varied in size, shape, aggregation, and habitats that we are only beginning to comprehend the scope of these unique species. Although there are no really authentic measures of the potential of the world squids, the total is certainly enormous. In the waters near the Americas there are about 80 squid species, of which more than 70 are found adjacent to North America (Lane, 1960).

In a recent (1973) (Voss, Gilbert L. "Cephalopod Resources of the World" FAO Fisheries Circular No. 149) review of world squid and octopus potentials, Voss indicated that the present catch for the Northwest Atlantic (Eastern North America—Mexico) is about 27,000 tons with an estimated potential take of up to 500,000 tons. Most of the present catch consists of two species, the short-finned squid, *Illex illecebrosus*, and the long-finned squid, *Loligo pealei*.

SHORT-FINNED SQUID

Canadian and American fishermen have never been aggressive in fishing for squids in the waters of the Northwest Atlantic. In Canada there has been a traditional fishery for the short-finned squid (Figure 1) (*Illex illecebrosus*). This squid has been valued primarily as bait and is caught by "jigging" (Figure 2). Up to the present this fishery has been a "passive" one, that is, fishing is carried on only in coastal Newfoundland waters during the summer period when squids have migrated there. Variations in seawater temperature and other hydrographic conditions appear to control the local (inshore) abundance of squid; consequently fishing results are dependent on environmental conditions (Mercer, 1970).

The short-finned squid, object of a traditional fishery in waters adjacent to Newfoundland, represents one variety of at least three different species of the same genus present in waters of the Northwest Atlantic (Roper et al., 1969). Mercer (1970) indicates that the annual catch may vary from insignificant amounts up to 11,000 tons during a single season. On the basis of pilot whale catches and their known consumption of this squid species as food, he speculates on the minimum standing crop of the short-finned squid as occasionally exceeding 4-5 times the greatest catch in the existing fishery (put another way, at least 50,000 tons). Soviet fisheries studies conducted aboard the exploratory vessel *Argus* in June 1971 (Noskov and Rikhter, 1971) revealed quantities of this species off southern New England. The above authors stated that there was a "relatively high abundance" of the short-finned squid along the edge and outer portions of the continental shelf from western Nova Scotia to Long Island. Unpublished data resulting from groundfish surveys conducted by the NMFS Northeast Fisheries Center indicate wide distribution of this species over the continental shelf in the fall (Sep-

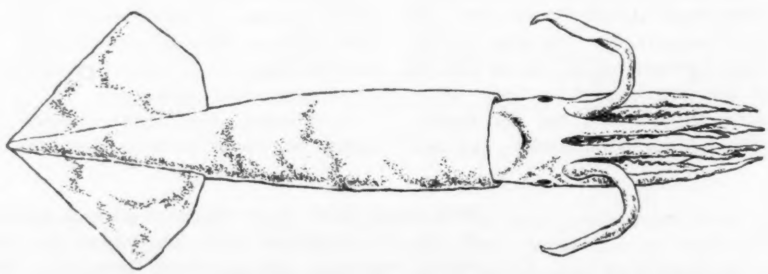


Figure 1.—One of the most common squids known from the continental shelf area in the Northwest Atlantic, the short-finned squid, *Illex illecebrosus*.

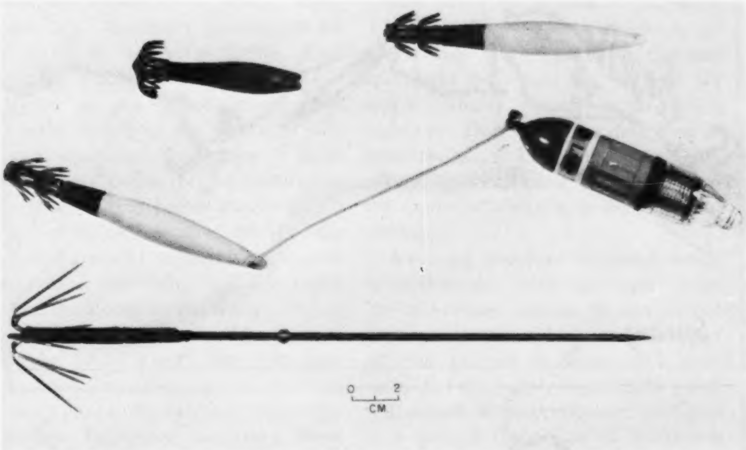


Figure 2.—Typical squid jigs: Newfoundland jig, top left; Japanese jig without light, top right; Japanese jig attached to light, center; mid-Pacific jig, bottom. In use, the jigs are attached to a line which is moved in a manner to simulate prey. After being attracted, the squid are impaled on the barbs.

tember-November) with contrasting restricted distribution along the edge of the shelf (more than 80 m) during the cooler spring (March-May) period. Progressing into more southern areas, south and west of Cape Hatteras, this species appears in deeper waters where it is known as far south as Florida (Roper et al. 1969). In reporting on direct observations of squid from the submersible *Alvin* off Cape Hatteras, Milliman and Manheim (1968) reported on concentrations of squid believed to be short-finned squid at depths of 220-250 m and 490-510 m. Squid were more numerous in the shoaler depth, where it was estimated that there were 500 individuals per 1,000 cubic meters of water. These observations were made in June and water temperatures at the depths where squid were observed ranged from about 5 to 15°C. This range of temperature is in close agreement with optimal temperatures in short-finned squid habitat off Newfoundland of 7-15°C (Squires, 1957). Voss (1971) mentions similar observations made off Miami at greater depths (ca. 650 m) from the *Aluminaut*.

Very little is known concerning the winter distribution of the short-finned squid and there are virtually no details of its reproductive habits. In a review of the species Nesis (1968) summarizes much of the available information. Interesting biological details provided include growth, which averages an eightfold increase in weight from 50 to 450 grams between May and October and death following spawning at the end of the second year.

All squid are known to be voracious feeders; the short-finned squid well illustrates this point. The young live on a diet which consists predominantly of small crustaceans gradually changing to young fish including cod, haddock, ocean perch, flounders, herring, mackerel and others. In addition to this varied diet the short-finned squid may also be cannibalistic, feeding on smaller individuals of its own kind (Nesis, 1968).

Squid jigging remains the basic approach to squid harvesting in Canadian-Atlantic waters. Commercial trawling for short-finned squid as the primary species was started experimentally by the Japanese during 1972.[1]

LONG-FINNED SQUID

Long-finned squid (*Loligo pealei*) (Figure 3) is known in North America as the bone squid, the common squid, and the winter squid. In southern New England during the summer this squid is often seen near docks at night attracted by lights. Pound net fishing, which was an effective method of harvesting during the late 19th and early 20th centuries, often yielded catches of long-finned squid (True, 1887). Not only pound nets fished on both sides of Cape Cod, but those farther south also often took squid. Pound net operations in waters adjacent to Delaware Bay took squid in significant amounts during the period 1949-1954 (June and Reintjes, 1957).

A characteristic feature of the biology of the long-finned squid is an annual inshore migration in the spring season (Figure 4). Spawning takes place at this time in waters from the shore to depths of about 90 meters

[1] Anonymous report in *Boston Market News*, 28 August 1972.

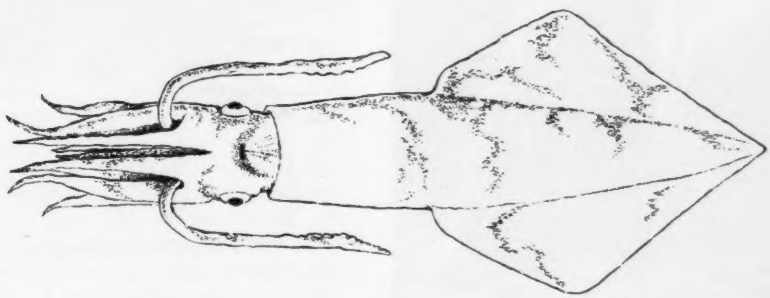


Figure 3.—The long-finned squid, *Loligo pealei*, long considered valuable for scientific study, is now the object of a growing fishery off the east coast of the United States.

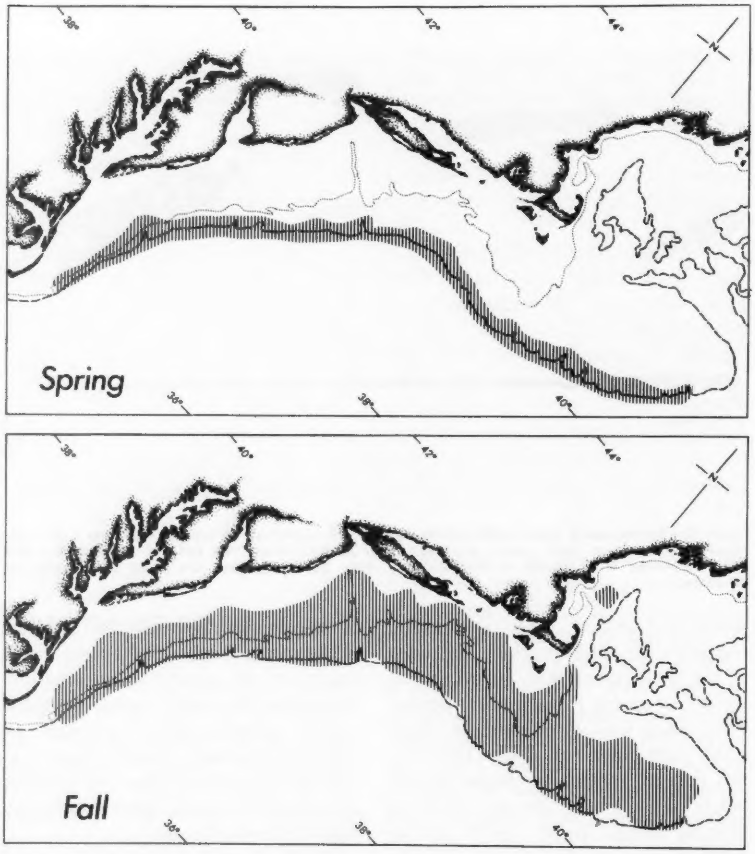


Figure 4.—Shaded area represents typical distribution of long-finned squid over continental shelf in the spring (March-May) and fall (September-November). Data have resulted from Northeast Fisheries Center groundfish surveys which do not cover areas of less than 27 meters.

(Verrill, 1882); the young squid remain in coastal waters until fall (mid-November in Martha's Vineyard waters, according to Summers, 1968). Heavy concentrations of long-finned squid aggregate in the vicinity of the outer continental shelf during the cool season (November-March); it is at this time that an international fishing fleet takes quantities of them. Perhaps the heaviest fishing on the squid stock at this season has been prosecuted by the Japanese, who began regular seasonal fishing off the U.S east coast about 1969. Catches by the large Japanese stern trawlers have averaged 10 or more tons per fishing day. Since 1969, others have entered the fishery

Figure 5.—Examining a catch of the oceanic squid, *Pholidoteuthis adami*, taken by shrimp trawl fished from the *Oregon II* off the coast of Surinam. These specimens were taken from 841 meters.

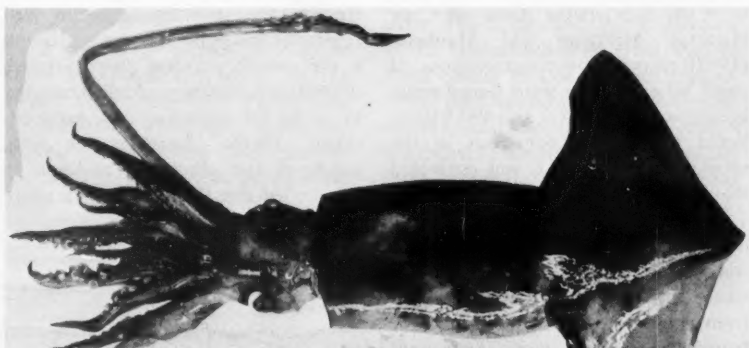


Figure 6.—The orangeback squid, *Ommastrephes pteropus*, broadly distributed over wide areas of the warmer oceanic Atlantic. Clarke (1966) states that "there is no doubt" that this species is present in enormous numbers where they occur. This specimen was from the Caribbean Sea.

including vessels from Spain, Italy, Cuba, West Germany and several of the European countries (USSR, East Germany, Poland and others).[2]

There is not much information available detailing the extent of the present resource. Squid have a short life span with most of the population of squid expiring before reaching two years of age (Summers, 1968). This fact alone would suggest that a poor year class (incoming broods) could reduce the stocks dramatically.

Soviet research on this species, summarized by Vovk, 1969, indicated dense concentrations (up to 200 tons of squid per square mile) near Wilmington and Baltimore canyons. These observations were made for the period February through April. It was stated that during this period catches by a BMRT-type vessel (ca. 2,000 hp) could be expected to reach 10 to 12.5 tons daily. These rates are similar to those experienced by comparably sized Japanese vessels.

Based on bottom trawl survey data generated from the research cruises of *Albatross IV* of the Northeast Fisheries Center, Edwards (1968) estimated the standing crop of long-finned squid between Nova Scotia and Cape Hatteras to be about 318 thousand tons. Japanese Fisheries Reports have indicated winter-season (December-February) catches of up to 15,000 tons by about a dozen vessels.

OTHER SPECIES

In addition to the squid species discussed above there are a number of other squid varieties distributed along the continental shelf area of the western Atlantic. These include the "arrow squid," *Loligo plei;* the "brief squid," *Lolliguncula brevis;* and others.

Off the continental shelf and approaching the ocean depths somewhat more exotic and lesser known species are recorded. One of these (as yet without a common name), *Pholidoteuthis adami*, is illustrated in Figure 5. Voss (1956) mentions schools of this species in the Gulf of Mexico and speculates that they may be prey for sperm whales which occur there regularly. This squid was described as recently as in 1956, but is possibly present in much greater numbers than the sparse information available would indicate.

A second moderate size squid, which is commonly observed near ships laying to over oceanic depths, is the "orangeback squid" *Ommastrephes pteropus* (Figure 6). Voss, 1971, indicates that the supply is probably great.

It would be inappropriate to engage in a general discussion of Northwest Atlantic squids without mention of the "giant squid" *Architeuthis* sp. (Figure 7). In a recent (1966) account Clarke summarizes some of the widely varying material recorded for giant squid over the past century. The following facts are extracted from his report.

1. Size—occasionally reaches 60 feet in total length.
2. Species—about 20 species accounts in the literature.
3. Probable habitat—200-400 meters or deeper.
4. Weight—possibly over one ton (1,000 kg).

One reason we know so little of the giant squid results from our inability to capture them easily. Practically all, if not all, records are the result of wounded or otherwise incapacitated squid drifting ashore or being found on the surface by a vessel.

This brief discussion offers only a smattering of what is known; much more is unknown regarding squid biology, distribution, and abundance. Reviews of the oceanic squids provided by Clarke (1963, 1966) indicate our knowledge of these animals is extremely fragmentary due to sampling problems. Some of the information on oceanic squid distribution has become available by examining stomach contents of large pelagic fish (i.e., tunas) and various mammals such as porpoises and whales.

HARVESTING

Fishing Gear and Technology

Japanese fishermen are by far the most proficient harvesters of squid. Of the total domestic Japanese landings of squid, one species stands out as the most important: the common squid of Japan, *Todarodes pacificus*. This species has accounted for annual catches of over 600,000 tons (1952) and typically represents 85 to 90 percent of all the squid and octopus taken by Japanese fishermen who in turn can be expected to take more than half of the world catch. In some years 90 percent of the catch of Japanese common squid is taken by "squid angling." The squid are attracted to the catching vessel at night by lamps. The squid are then caught on jigs fished either by individual fishermen (up to 35) or by automatic "squid jiggers." In addition to this technique a substantial part of the catch (up to 10 percent) is sometimes taken by various set nets. Other types of gear are insignificant (Anon., 1958).

In the Northwest Atlantic, as in Japan, jigging is the most important fishing method in Newfoundland waters when fishing for the related species (*Illex*). In a discussion of the adaptation of mechanical Japanese jigging equipment to the Newfoundland fishery, Quigley (1964) cites one instance when a vessel with automatic "jiggers" took about two tons during one hour of fishing on the same grounds in which a vessel fishing with traditional hand-operated jigs took only 15 percent of that amount.

The Japanese fishery off the east coast of the United States, now in its fifth year, uses large trawl nets. Vessels (1,500-1,900 gross tons) with up to 2,700 hp fish trawl nets and average about one ton of squid (*Loligo*) for each of 10 trawl tows taken during a 24-hour period. Catches tend to be heavier during daylight hours than at night,[3] reflecting the habits of the squid.

[2] Various NMFS sources, primarily Market News and International Activities Staff reports.

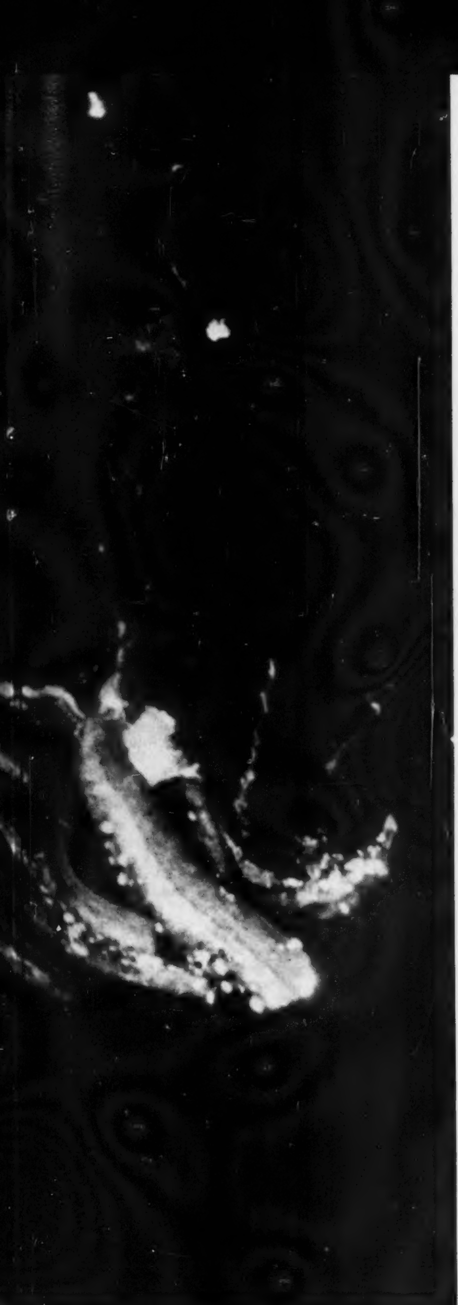
[3] Personal communication by NMFS personnel with Japanese fishermen.

Figure 7.—Giant squid about 47 feet in overall length taken by the vessel *Silver Bay* off the coast of Florida. This specimen was later deposited in the collection of the University of Miami. Only rarely are such specimens obtained.

Most fishing is done near the edge of the continental shelf in the general vicinity of the Hudson Canyon, during winter months of December through March.

In addition to Japanese vessels, others from Spain, Italy, West Germany, USSR and other countries are sometimes represented in this fishery. United States fishermen fishing the same areas have traditionally taken some squid while trawling along the outer continental shelf during the winter season. Most of the U.S. domestic catch has been incidental to trawling for other species. This catch has been consistently under 2,000 tons a year.

Almost one hundred years ago in pound net (trap) fishing along the mid-Atlantic states from Virginia to Massachusetts quantities of long-finned squid were taken during their inshore migration. One reference to the large numbers sometimes taken was provided by True (1887) in which he cites an occasion when pound nets installed along the Long Island shore averaged 15 tons of long-finned squid daily for



a period of six weeks during the latter part of May through June 1887. Discussions with various individuals on Cape Cod have indicated that good catches of squid are still accounted for occasionally in the now dwindling number of pound nets fished there. Due to lessened availability of fish, pound net gear is rapidly disappearing from the mid-Atlantic states.

Small amounts of squid are sometimes taken by midwater trawls but records of significant landings using this fishing gear are not available. It is possible to speculate that the technology of midwater trawling may be upgraded to the point where it is effective on certain species of squid.

Locating Squids

A number of possibilities exist for measuring the abundance and distribution of squids which, due to their elusive habits, are only poorly sampled by trawl nets.

Japanese research has demonstrated the potential of detecting squids with echo sounding equipment (Anon., 1972). When this method is refined, it may be used for effectively locating and estimating stocks of squids and other pelagic species.

Photographic techniques have been employed by British researchers Baker (1957) and Clarke (1966). This method is particularly attractive for high seas studies and involves the use of undersea cameras with bait. Direct observation from a submersible vehicle has been described by Milliman and Manheim for the waters adjacent to Cape Hatteras, N.C.

Squire (1972 and personal communication) has indicated that schools of squids are sometimes detectable at night from aircraft over California waters. This opens the possibility for the eventual employment of low-light sensing as described by Roithmayr (1970). Ultimately remote sensing via satellite may be a potential tool in measuring squid and other resources.

Technological Advances

One of the more interesting developments in fishing technology was recently reported by Kato (1970). West coast squid (*Loligo opalescens*), close relatives to our east coast long-finned squid, were attracted to a fishing vessel with lights and pumped aboard the vessel. The system has harvested as much as 10 tons of squid during 15 minutes (Figure 8). On occasions up to 50 tons of squid have been harvested in this manner in a single night, though traditionally these west coast squid have been harvested primarily by small seines and lift nets. This experience suggests that some species of squid may be rational targets for large automated fishing platforms (Figure 9) such as that suggested by Klima and Roe (1970). In addition to behavioral response to light, certain squid species tend to aggregate in particular thermal conditions. This characteristic might become apparent in the future when seabased power generating operations come into being.

A scientist working at the University of Miami recently demonstrated the ability to raise a tropical Loliginid squid from egg to maturity in only five months (Anon., 1970). This interesting accomplishment opens for speculation the potential of aquaculture methods in raising squid.

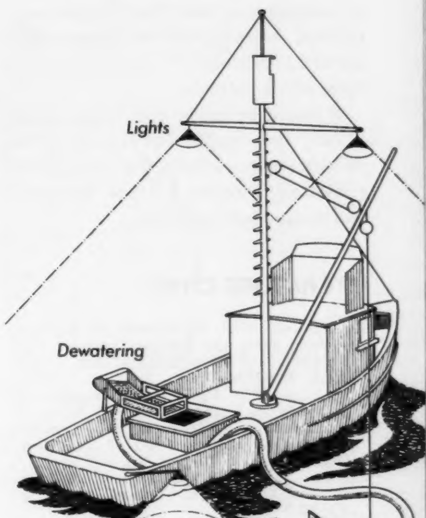


Figure 8.—Schematic view of squid harvesting system utilizing light attraction and mechanical pumping. This technique has been used effectively off California.

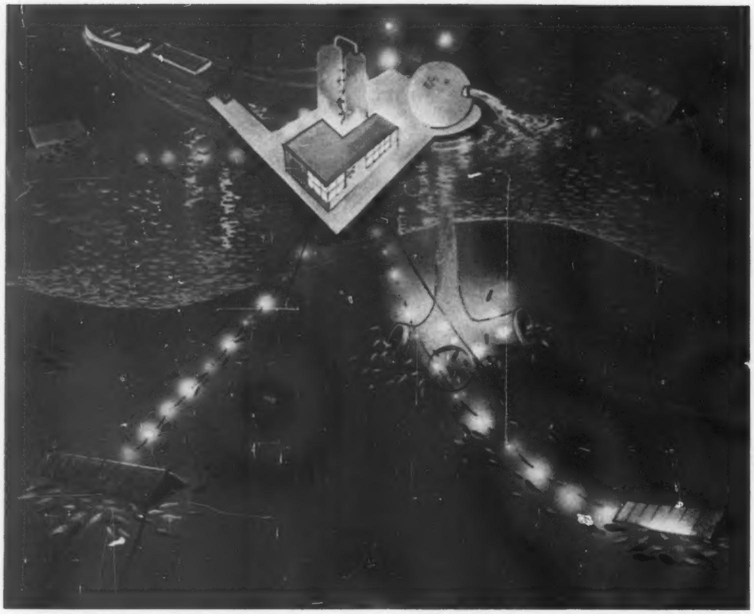


Figure 9.—Conceptual view of proposed automated fishing platform. This scheme might be adaptable to harvesting some species of squid which are attracted to light and are responsive to certain temperature conditions. (From Klima and Roe, 1972.)

In a recent review of world fisheries potentials, Suda (1972) suggested a possible range for potential increase in the world catch of 43.1-55.3 million metric tons over the present catch. It is significant to note that his estimates include cephalopods as representing about 13 percent (5.7-7.0 million metric tons) of the increase.

It may even follow that in the United States the trend toward liberated palates may relax the traditional resistance here to a truly delightful and unique seafood treat.

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MFR PAPER 1024

Long-haul fishing, as developed in North Carolina's Carteret County at the turn of the Century, is still an economical and efficient method of harvesting fish in shallow water.

The Long-Haul Fishery of North Carolina

JAMES F. GUTHRIE, RICHARD L. KROGER, HERBERT R. GORDY, and CURTIS W. LEWIS

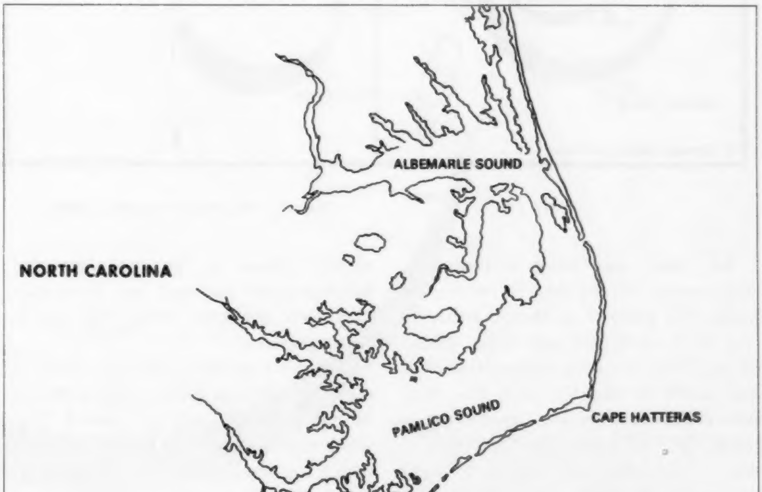
ABSTRACT

Methods and gear used in the long-haul fishery of North Carolina are described. Long-haul fishing, in which a 1,000-yard by 6-foot deep net is pulled up to 5 miles before the fish are landed, is especially adaptable to shallow-water areas with unobstructed bottoms. Sufficient detail is given to enable the reader to adopt the method for fishing in other areas.

INTRODUCTION

Long-haul fishing has been used to harvest fish in the shallow, inside waters of Albemarle, Pamlico, Core and Bogue sounds, North Carolina since the early 1900's (Figure 1). In long-hauling, a 1,000- to 1,200-yard 6-foot deep net is pulled between two boats for up to 5 miles before the fish are encircled and concentrated by pulling the net around a stake (Figure 2). Long-haul fishing is somewhat unique because the cork line remains a few feet (dependent on depth of the water) under the water surface during the haul but the lead line remains on the bottom. Bottom fish and most others leisurely swim ahead of the slow moving net instead of escaping over the sunken cork line and do not try to escape. At the end of the haul they are trapped in a deeper section of net whose cork line floats at the surface. The methods of long-haul fishing should be applicable for harvesting fish in other shallow water areas with unobstructed bottoms. In this paper we describe the gear and methods used by fishermen from Harkers Island in Carteret County, and give a brief history of the fishery and catches.

Figure 1.—Long-haul fishing areas in North Carolina.



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DESCRIPTION OF THE LONG-HAUL GEAR

The long-haul net is divided into six or eight sections 100 to 150 yards long that are called wing and back nets (Figure 3). Since the cork line of the net is under the water surface when being pulled, a floating buoy is attached to each section to warn vessels from passing over and fouling the gear. In this report our discussions pertain to nets composed of eight sections, four wing and four back nets.

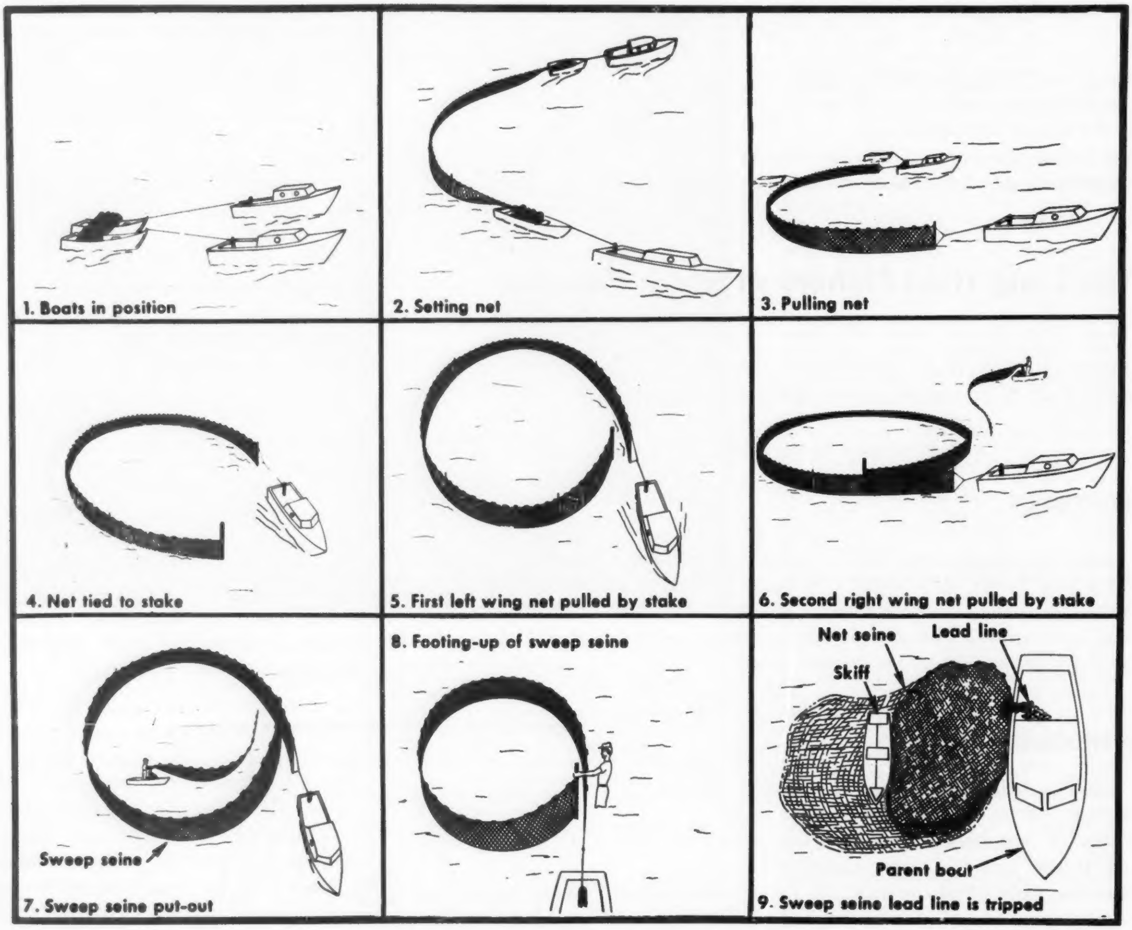

Figure 2.—Sequence of long-haul fishing.

All back and wing sections are constructed of number 9 twine and hung with number 18 thread twine on $^7/_{16}$ or ½-inch poly-type rope. Depth of the 2-inch bar wing nets is 30 meshes and depth of the 1⅛ inch bar back nets is 65 meshes. The typical net is taken up five meshes in the space of three. Two and one-half inch corks are placed on every fifth knot or with four ties between corks. Three 2-ounce leads are used for every three corks on both wing and back nets. In each section of net the lead line is 2½ to 3 yards longer than the cork line which allows the cork line to float higher and slightly ahead of the lead line and helps prevent the lead line from cutting into the mud while the net is being pulled.

The two center back nets have a staff on each end where the two halves of the long-haul net are joined. The wing nets are put together by beckets which are overlapped 7 to 9 feet (Figure 3, insert). A staff, 7 feet long and weighted on the bottom, is attached to each end of the long-haul net and a 75-foot, ½-inch poly-type tow rope is attached from the staff to a pull boat. The two pull boats range from 20 to 45 feet long and are powered with six or eight cylinder automobile engines or marine diesels (Figure 4). Two skiffs about 18 to 24 feet long and 7 feet wide are used to carry the nets. A six-man crew is normally used.

The 75-yard long sweep seine, which is much deeper and whose cork line floats at the surface, is put overboard at the end of the haul to hold the fish. It has ⅞-inch bar mesh and is constructed of number 9 twine and is 150 meshes deep except for the bail-bunt end (the last 7 to 10 yards), which is 200 meshes deep and constructed of number 12 twine. In the bail bunt, 4-inch corks are hung solid

and three 2-ounce leads are put in each tie. In the rest of the sweep seine the corks remain almost solid but, are reduced in size and only two 2-ounce leads are used in each tie.

METHODS OF LONG-HAUL FISHING

In preparing to make a haul, the crew place the back and wing nets aft aboard the two skiffs with the cork lines facing the bow to prevent lead and cork lines from crossing as the net is set. The sweep seine, which is put out by hand, is placed in the middle of the largest skiff with the cork line facing aft. When the nets are ready to be fished, the staffs of the two back nets are lashed together. The pull boats take the skiffs in tow and pull the back and wing nets out of the skiffs in the direction the haul is to be made, usually with the ebb tide because the net is too large to pull against a current (Figure 2). After the entire net is in the water, the tow rope is hooked directly from the pull boats to the staffs. The skiffs are towed and are used to free the net if it becomes tangled.

Long-hauling is carefully timed to enable the nets to be landed on slack tide at a predetermined shallow-water landing point, sometimes more than 5 miles away. If timing is off and the net is too far away from the intended landing point when the tide changes, the haul is terminated. If the haul goes well, a skiff is sent to the shallow-water area (the water must be shallow enough to enable the crew to stand on bottom) to plant a 3-inch diameter "footing-up-stake" which is used in concentrating the fish in the net.

Sections of net are cut-out after they have been pulled by the stake. The crew on the lead pull-boat (right, in our discussion) tie the end of the net to the stake and anchor their boat so they can assist in cutting-out sections of net (Figure 2). After the right end of the net is tied, the left boat pulls

Figure 3.—Components of a long-haul net.

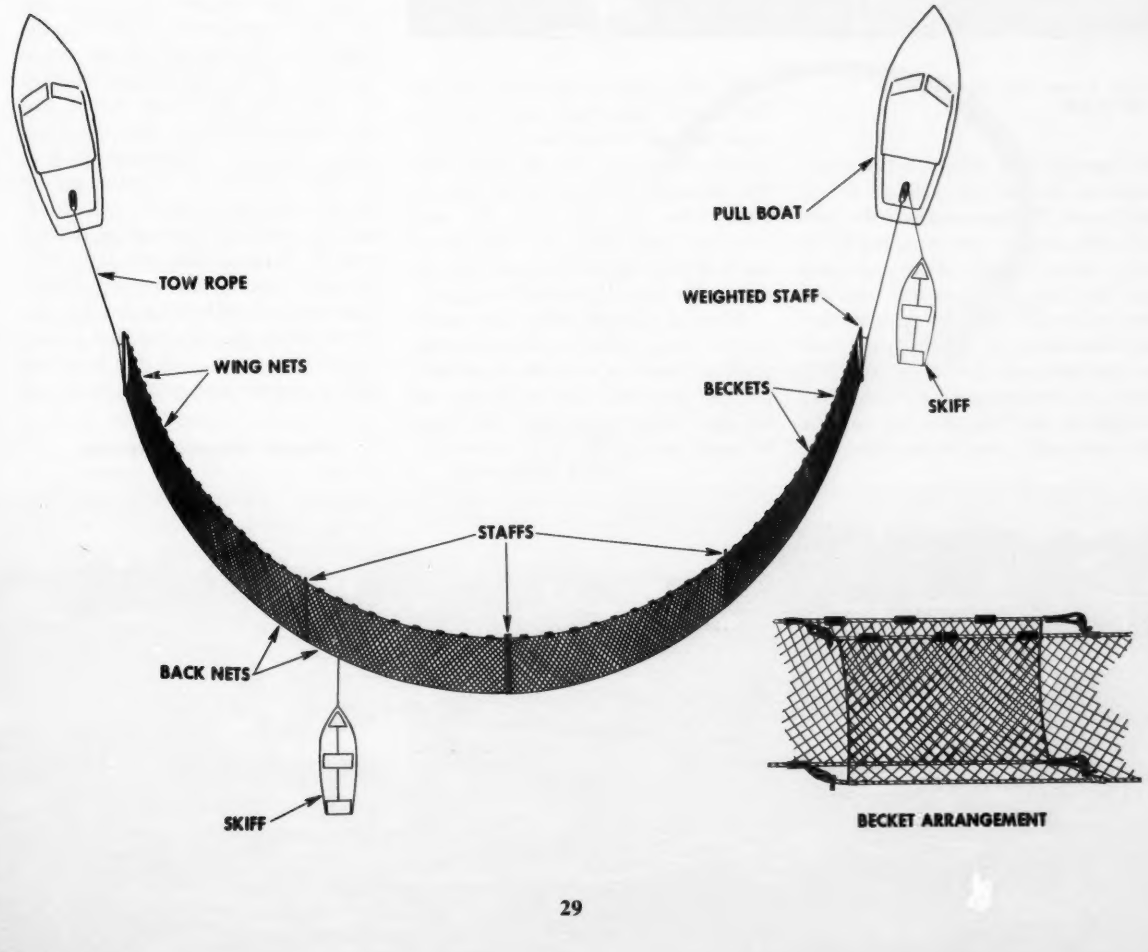

Figure 4.—Pull boat loaded with a catch of spot.

the first left wing section by the stake, which is cut-out and taken-up by the skiff crew. The boat returns to the stake and pulls the first right wing net by the stake, which also is cut-out and taken up. The process is repeated until the second left and second right wing nets are taken up. After the first right back net has been pulled by the stake 50-70 yards, the sweep seine is put out on the outside of the long-haul net and the bail-bunt end is tied to the stake. The other end is tied to the front staff on the second right back net. The first right back net is then taken up on the inside of the net. As the boat pulls the remaining sections of net by the stake from the left and the skiff crew cut them out, one man keeps the lead line footed-down and the net against the stake if fish begin escaping.

After all sections have been taken up, the sweep seine is pulled past the stake by hand or with the boat until the bail-bunt end staff is tripped (all the lead line is taken up). Care must be taken to keep the lead line on the bottom and the loose net of the seine against the stake or the entire catch can escape. The sweep-seine net is handled in much the same way as a purse seine and the fish are dip-netted from the bail bunt into the boat. If the catch is extremely large and the end staff cannot be tripped, the sweep seine has to be staked-up with oars or saplings (Figure 5) and the fish taken out of the sweep seine with a hand-pulled trawl which is swept across the seine. After sufficient fish have been removed by the trawl, the sweep-seine staff can be tripped and the remaining fish removed with dip nets.

A modified method of long-hauling has also been developed in recent years and it utilizes a net called a "swiper." The net consists of one-half of a regular long-haul gear (two wing and two back nets) with a sweep seine attached to the rear staff of the second back net. With this "swiper" method the bail-bunt end of the net is tied to a footing-up-stake and the other end is pulled in a wide circle back to the stake (Figure 6). "Footing-up" of the net takes place, as in regular long-hauling, when the sections are pulled past the stake and cut out. Individual "swiper" catches are usually smaller than regular long-haul catches because of the small area covered, but a crew of only three with one pull boat and skiff is needed and several hauls can

Figure 5.—Sweep seine staked-up.

be made per day. The method is especially adaptable for hauling small areas where fish are known to be abundant, whereas regular long-hauling can be profitably used in large areas where fish are not concentrated.

HISTORY OF LONG-HAUL FISHING

Long-haul fishing was evidently developed in Carteret County, N.C., which still leads in production from this gear. According to older fishermen the fishery started around Atlantic, N.C. in about 1910. The fishery, initially conducted only in October and November, was designed especially for spot, *Leiostomus xanthurus*, which was abundant and could be more profitably fished than other species. Prior to 1910 the catch of spot in North Carolina was less than one-half million pounds. After development of the long-haul fishery, annual catches between 1910 and 1930 often reached 5 million pounds (Taylor, 1951).

The present fishery starts in early July, continues into November, and still concentrates principally on spot. Now, however, large quantities of bluefish, *Pomatomus saltatrix;* Atlantic croaker, *Micropogon undulatus;* pigfish, *Orthopristis chrysopterus;* weakfish, *Cynoscion regalis;* and northern kingfish, *Menticirrhus saxatilis*, are taken as well as small quantities of other edible fish (Table 1). Before 1964, records of catches for common haul seines and long-haul seines were not separated. Since 1964, catches from "swipers" are included with those made with regular long-haul gear. Although not recorded, the highest known catch for one haul in modern days was 258,000 pounds of spot, which was taken in Pamlico Sound, N.C.

Long-haul fishing became more effective when nylon nets replaced cotton nets. Nylon nets were lighter and easier to handle, and the cork line did not sink as far under the water surface. With cotton nets the cork line stayed about 3-4 feet off the bottom when being pulled, whereas the cork line on nylon nets fished 5-6 feet off the bottom. Because of the increased efficiency when using nylon nets, long-haul crews can make two hauls per day.

In the past when many long-haul crews were fishing in the same general areas, selection of the preferred hauling sites was determined before the season began by a drawing. This method eliminated fierce competition and fishermen willingly abided by the results of the drawing. The order of hauling was broken only with the permission of the crew which was scheduled to haul on a given day.

A reduction in fishing effort in

Figure 6.—Sequence of swiper-net fishing methods.

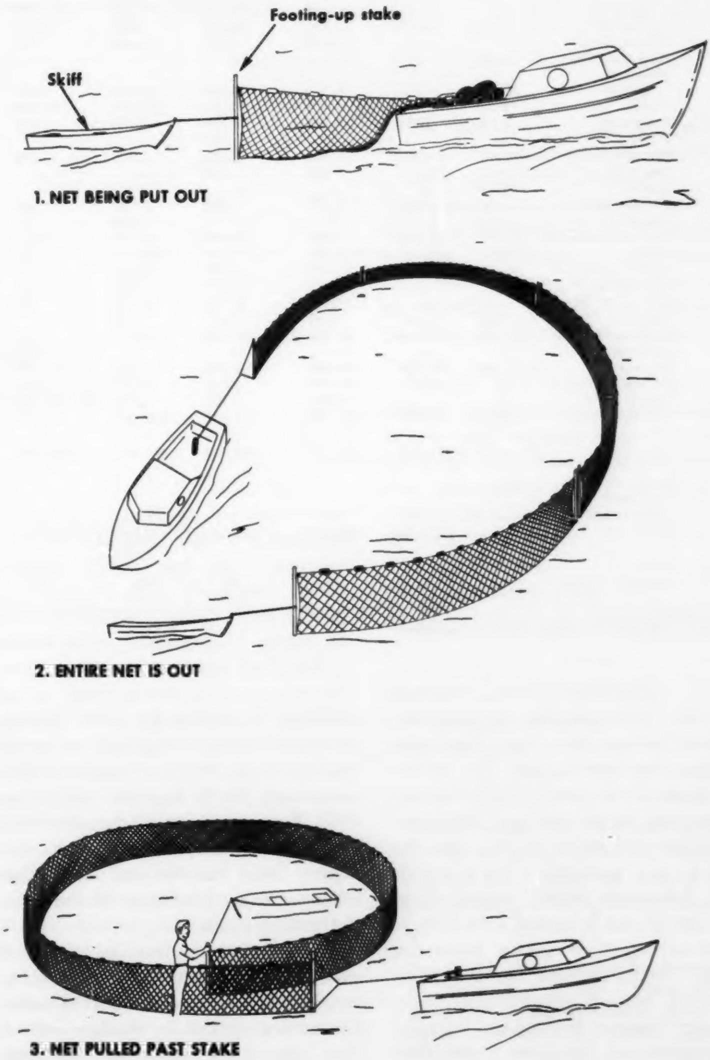

Table 1.—Pounds of fish landed and sold, dockside value of catch and number of long-haul crews in operation from 1964-1972. Data from the National Marine Fisheries Service, Branch of Statistics, Beaufort, N.C.

Species	1964	1965	1966	1967	1968	1969	1970	1971	1972
					Catch in Pounds				
Alewife	—	—	1,000	35,200	76,100	115,000	30,000	—	—
Atlantic croaker	309,500	234,000	137,400	273,800	178,100	126,300	133,000	204,300	677,464
Atlantic menhaden	27,600	26,200	5,200	5,000	20,000	—	—	—	—
Black drum	2,600	10,700	30,500	14,700	9,400	2,700	3,100	4,000	5,511
Bluefish	144,500	180,600	281,400	314,300	506,200	333,800	245,400	215,500	403,648
Butterfish	34,000	82,200	33,500	10,800	18,900	2,800	300	500	5,464
Carp	—	—	71,100	40,300	—	3,700	—	800	—
Cobia	10,300	7,400	7,700	10,000	6,600	6,300	6,300	10,300	2,609
Eels	—	—	800	—	—	—	—	—	—
Freshwater catfishes	—	—	58,300	18,100	700	14,500	—	3,200	—
Harvestfish	13,500	42,300	22,900	54,900	6,900	13,700	9,200	23,700	24,121
Hickory shad	—	—	13,800	500	22,300	300	—	—	—
King mackerel	6,400	—	—	—	—	—	—	—	—
Northern kingfish	82,800	85,000	10,100	23,400	15,500	4,600	19,200	31,600	22,340
Pigfish	29,500	27,800	41,100	90,500	90,800	156,000	145,900	189,500	137,601
Pompano	2,300	5,100	9,900	28,200	5,800	3,000	2,000	2,200	4,357
Porgy	—	—	500	600	—	—	—	—	—
Red drum	84,400	58,000	21,700	4,900	7,400	1,200	2,400	3,100	5,551
Sea bass	—	—	300	600	—	—	—	—	—
Sharks	3,500	—	—	—	3,100	—	—	—	—
Sheepshead	2,800	3,900	5,100	2,300	2,000	1,000	800	3,700	2,141
Spadefish	2,100	200	—	—	1,600	300	1,600	3,900	634
Spanish mackerel	33,600	37,200	9,300	34,800	28,900	74,800	33,200	26,600	7,178
Spot	528,500	358,000	532,600	1,501,300	988,800	702,900	1,098,200	808,400	2,130,444
Spotted seatrout	62,700	80,300	51,800	22,200	27,200	49,900	107,300	87,400	274,370
Striped bass	—	—	32,800	56,500	25,300	17,500	—	6,200	300
Striped mullet	—	—	48,900	60,300	15,600	900	400	—	1,831
Sturgeon	4,900	10,800	300	100	200	—	—	300	100
Summer flounder	161,200	286,400	67,400	29,000	50,900	6,900	4,600	2,100	13,608
Swellfish	—	—	—	—	—	1,400	—	2,200	—
Weakfish	97,300	105,000	180,800	269,800	154,400	184,300	187,700	168,400	255.289
White perch	—	—	22,200	8,600	4,200	3,600	—	—	100
Yellow perch	—	—	5,300	7,100	2,500	2,200	—	—	200
Miscellaneous	75,000	87,500	521,700	271,700	648,500	178,700	—	613,000	—
Total Catch	1,719,000	1,728,600	2,225,400	3,189,500	2,917,900	2,008,300	2,030,600	2,410,900	3,974,861
Value in dollars to fishermen at dockside	192,731	183,295	162,175	244,983	277,043	227,751	198,480	233,066	444,948
No. of long-haul crews	35	33	45	47	40	37	34	24	[1]

[1] Information not available at present.

previous years (Table 1) probably resulted because there was often only a market for fresh-caught spot in the first weeks of the fishery. After making a few big initial catches, fishermen could not sell their fish because the market was saturated. As a result, some fishermen began storing large amounts of spot in rented, cold storage plants in hopes of selling when the market improved later in the year. Handling, boxing, and freezing costs, however, reduced profits so as to make it unfeasible to fish some years. This probably accounted for some of the decrease from 13 long-haul crews on Harkers Island, N.C. in the mid-1950's to three in 1972. Because catches in 1972 were good and market demands improved from previous years, we expect the number of long-haul fishery crews to increase in the area of Harkers Island, N.C.

The previous history and present status of long-haul fishing indicate that it is still economical and efficient for harvesting fish in shallow water. The cost-return ratio, as in other fishing operations, for long-haul fishing is dependent on fish abundance, market value of the fish and duration of the fishing season. In North Carolina, long-haul fishing remains somewhat profitable, even in years of low abundance or low market prices, because fishermen use their boats in other fishing operations the rest of the year. Rather than enter long-haul fishing with new equipment which could involve a sizeable investment for two pull boats, two skiffs and the nets, it would be more economical

for a fisherman to obtain used equipment or modify gear used in other fishing operations.

Long-haul fishing with "swiper nets" is becoming more popular in certain North Carolina areas. This method has almost completely replaced the traditional long-haul method in portions of Pamlico Sound but no "swiper" nets are presently known to be used in the Harkers Island area. We do not have any knowledge of the comparative cost-return ratio for the two methods but suspect that it varies among different types of areas.

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MFR PAPER 1025

Midwest retailers report dieters are having a pronounced positive effect on fish sales.

LEONARD J. KONOPA

Marketing Practices of Retailers Handling Fish in the Akron and Cleveland Areas

In the September 1973 number of *Marine Fisheries Review* (Vol. 35, No. 9, p. 31-37), the results of an exploratory survey concerning the marketing practices of wholesalers located in Akron and Cleveland, Ohio, were reported. Interviews were also conducted with retailers in the channel of distribution at the same time (spring and summer, 1971). These findings are summarized in this article.[1]

SURVEY METHODOLOGY

All of the general line and specialty line retail grocery establishments listed in the yellow pages of the *Akron and Vicinity Telephone Directory* (Summit County, Ohio) and the *Cleveland Metropolitan Area Telephone Directory* (Cuyahoga County, Ohio) were contacted by telephone to determine whether or not they sold fish; and, if so, the form of fish (fresh, frozen, or canned) they handled. A random sample of nonchain retailers was then selected from the list of retailers who carried any form of fish. Chain store retail outlets (centrally owned and centrally directed units) were selected similarly at random, but fewer stores were chosen because the retail outlets of a given chain ordinarily operate in the same manner. Comparisons of replies of store managers within the same chains, for example, reveal identical policies, attitudes, and methods of operation.

The interviewers arranged appointments by telephone with the randomly selected retailers to conduct personal interviews at the convenience of the store managers. When a store manager was unable to keep his appointment, a followup interview was conducted by telephone. A pretested, structured questionnaire was utilized in all interviews.

Overall, 115 retail outlets were selected in the random sample. Usable replies were received from 110 store managers. After the replies were edited, they were tabulated by means of a Cobal program written for this purpose.

DESCRIPTION AND CLASSIFICATION OF STORES

General Line Food Stores and Specialty Fish or Meat Markets

Retailers handling fish are divided into two major categories in Table 1. Category A contains the general line grocery stores offering fish; Category

[1] For the complete survey results, write to the author for a copy of the monograph "Survey of Selected Retail Food Stores Handling Fish in Cuyahoga and Summit Counties, Ohio," College of Business Administration, Kent State University, Kent, OH, 44242. The survey was sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 2-35364.

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Table 1.—Type of stores grouped by annual sales.

TYPE OF STORE	Group 1 Sales to $99,999	Group 2 $100,000 to $499,999	Group 3 $500,000 to $999,999	Group 4 $1,000,000 and over	Total
	ANNUAL SALES GROUPS				
A. General Line Food Stores					
Independent Stores	24	12	11	1	48
Affiliated Stores	5	14	7	7	33
Chain Stores	0	0	0	17	17
Subtotal	29	26	18	25	98
B. Specialty Fish or Meat Markets					
Independent Stores	8	4	0	0	12
Affiliated Stores	0	0	0	0	0
Chain Stores	0	0	0	0	0
Subtotal	8	4	0	0	12
Grand Total	37	30	18	25	110

Source: Survey Results

B represents the specialty fish or meat markets handling fish. The fish markets, of course, specialize in the sale of fish, while the meat markets sell fish either as a major offering or as an accommodation for customers who desire fish.

Grouping by Annual Sales, Form of Ownership, and Operation

The retailers are further grouped in Table 1 by annual sales as well as by form of store ownership and operation. Classification of stores by amount of annual sales is self-evident. The ownership and operating characteristics by which various types of stores are differentiated, however, must be explained. *Independent* stores are individually owned and operated by their proprietors. They are not members of any wholesaling group or comparable association. *Affiliated* stores are also independently owned and operated, but they are members of either retailer- or wholesaler-sponsored voluntary groups. Such groups perform the wholesaling function for their members and typically provide marketing services which may range from advertising in local newspapers to the prepricing of products. *Chain* stores, as indicated heretofore, are centrally owned and operated by their managers in keeping with corporate policies and procedures.

Analyses of Types of Retail Stores

A review of Table 1 shows all 12 of the specialty fish or meat markets in the sample are independent stores while 48 of the 98 general line food stores are also independent. The grouping by annual sales further indicates that the independent stores are typically smaller establishments. Affiliated stores, on the other hand, are generally larger than the independents. As a matter of fact, seven of the 33 affiliated stores report sales of $1 million or more per annum. Lastly, the large size of the 17 chain stores is evinced by the fact none has annual sales under $1 million.

FORMS OF FISH HANDLED BY SIZE OF STORE

Forms of Fish Handled by General Line Grocers

The data in Table 2 show canned fish is carried by 98 percent of the general line grocery retailers. The second most popular product is prepared frozen fin- and shellfish with nearly 80 percent of the general line grocery stores offering prepared frozen finfish and approximately 70 percent stocking prepared frozen shellfish. The general line grocers' preference for frozen fish is further reflected by the fact 57 percent handled whole or processed frozen finfish while 47 percent sold whole or processed frozen shellfish. Whole or processed fresh finfish is found in 34 percent of the general line food stores. Whole or processed fresh shellfish is a scarcer commodity handled by 13 percent of the establishments. Similarly, only 5 percent offered prepared fresh finfish while one store (1 percent) handled prepared fresh shellfish.

Forms of Fish Handled by Specialty Markets

Among the specialty fish or meat markets, whole or processed fresh finfish is the most popular item with 83 percent (ten of twelve stores) handling fresh finfish. Only 33 percent, however, also stock whole or processed fresh shellfish. Interestingly, none of the specialty stores sell prepared fresh finfish or shellfish, although prepared frozen finfish is found in 42 percent and prepared frozen shellfish in 17 percent of the specialty stores. Whole or processed frozen shellfish are handled by more specialty markets than whole or processed frozen finfish (25 percent versus 17 percent). Finally, only 17 percent of the specialty stores stocked canned fish.

PERCENTAGE OF SALES BY FORM OF FISH HANDLED

General Line Stores

Analyses of each store's sales by forms of fish carried reveals four distinct trends among general line retail grocers. First, it is again evident that canned fish is the predominant form of fish carried by general line grocers. All but two of the 98 general line retail grocers stock canned fish. As a matter of fact, 12 of the 29 smallest groceries handle only canned fish. Among the 98 stores offering it, sales of canned fish represent 28 to 100 percent of their particular store's

fish sales. Second, the next most popular form of fish is prepared frozen fish. Sixty-seven of the 69 general line grocers with sales of $100,000 or more per annum offer prepared frozen fish to their customers, whereas 17 of the 29 smallest grocers (sales under $100,000) handle frozen fish as well as canned fish. Prepared frozen shellfish is offered by fewer stores than prepared frozen finfish, although there is a tendency to handle both as the stores become larger. Third, the retail unit is more likely to carry whole or processed frozen fish as the size of the store increases, until everyone does so among the group 4 stores (sales of $1 million or more per year). Here, too, fewer stores handle whole or processed frozen shellfish than frozen finfish, but there is a tendency to offer both whole or processed frozen finfish and shellfish as one progresses from the smallest to largest groups of stores. Fourth, there is a direct relationship between the size of general line grocery store and the sale of fresh fish. No one in group 1 (sales under $100,000) sells fresh fish; 19 percent offer fresh fish in group 2 (sales from $100,000 to $499,999); 50 percent handle fresh fish in group 3 (sales of $500,000 to $999,999); while 76 percent in group 4 (sales of $1 million or more) provide fresh fish.

Another way of utilizing the sales data is to construct a composite or typical profile of fish sales of all general line stores. Such a composite reveals that 53.5 percent of a typical store's full line fish sales would be canned fish; all forms of frozen fish would account for an additional 39 percent of its sales, while fresh fish would represent 7.5 percent of the store's fish sales.

Specialty Line

Unlike the general line retailers, group 1 (sales under $100,000) specialty fish or meat markets emphasize fresh fish. Five of the eight markets, for example, handle nothing but fresh finfish and/or fresh shellfish. The three other specialty shops in group 1 carry some form of prepared or processed frozen fish in addition to fresh fish.

Table 2.—Forms of fish handled by size and type of store.

	Form of Fish Handled								
	Whole or Processed				Prepared				
	Fresh		Frozen		Fresh		Frozen		
Type of Store and Size	Fin	Shell	Fin	Shell	Fin	Shell	Fin	Shell	Canned
A. General Line									
1. Sales under $99,000 [29]	0	0	7	3	0	0	14	7	28
2. $100,000 to $499,999 [26]	4	1	14	12	0	0	26	22	26
3. $500,000 to $999,999 [18]	9	4	12	9	1	0	14	15	17
4. $1,000,000 & over [25]	19	8	24	22	4	1	25	23	25
Subtotal	32	13	57	46	5	1	79	67	96
B. Specialty Line									
1. Sales under $99,999 [8]	8	4	0	1	0	0	2	1	1
2. $100,000 to $499,999 [4]	2	0	2	2	0	0	3	1	1
Subtotal	10	4	2	3	0	0	5	2	2
Grand Total	43	17	58	47	5	1	84	69	98

Source: Survey Results.

In contrast with group 1 specialty markets, each of the four markets in group 2 ($100,000 to $499,999 annual sales) carries some form of prepared or processed frozen fish while only two of the four markets handle fresh finfish. Group 2 specialty markets, consequently, resemble group 3 general line retailers more closely than group 1 specialty markets. Both groups of specialty markets differ from general line retailers, however, in terms of canned fish. Among both group 1 and group 2 specialty markets, only one market in each group distributes canned fish.

RETAILERS' MARKUP

Problems Relating to Markup Data

Several problems were encountered in gathering markup information. To begin with, some retailers did not know their initial markup on canned and/or frozen fish. In addition, others refused to disclose this information. Different employees, moreover, were responsible for fresh versus frozen versus canned fish in some of the stores. When interviewers were unable to talk with each of these individuals, the other interviewee(s) estimated the markups for the alternate forms of fish handled. Lastly, managers often gave markups purportedly based on the cost of goods, although markup on retail price was sought. In order to confirm the markup base used, several wholesalers as well as chain store warehouses were contacted. Wholesalers typically list the cost as well as suggested retail price on their forms. The markups given by retailers were not based on cost, but generally on the suggested retail price. The chain store warehouses which were contacted also reported their markups were on the retail price base for financial control purposes. Some of the markup data, consequently, had to be adjusted to the retail price base when it was evident that a discrepancy existed.

Summary of Markup Practices

Because of the problems encountered in obtaining markup information, it is difficult to generalize from these data. It is intriguing, nonetheless, to find so many stores utilizing a uniform markup policy. Seventy-five percent of the smallest general line retailers handling both canned and frozen fish, for example, mark up all forms of fish the same proportional amount. Fifty percent of the group 2 general line retailers also mark up all of the fish they sell the same proportional amount. Among the group 3 stores, only 17 percent determine retail price on the basis of a uniform percentage markup for fresh, frozen, and canned fish. The number of stores adopting a uniform markup on all forms of fish sold continues to decline

as the size of store increases until merely 5 percent of the retailers in group 4 employ a uniform markup policy. Despite the fact few retail managers in groups 3 and 4 implement a uniform markup policy on *every* form of fish handled, 60 percent mark up all fresh and frozen finfish and shellfish the same proportion of retail price while marking up canned fish a lesser amount. The markup policies of specialty line markets tend to parallel those observed among general line grocery stores. That is to say, two-thirds of the specialty outlets have identical percentage markups on retail price on all forms of fish carried in their respective stores. A uniform markup policy is simple to apply, but entrepreneurs fail to capitalize on the fact that higher value products like fresh shrimp or finfish are ordinarily capable of bearing higher percentage markups on their resale price than frozen shrimp or finfish.

Another intriguing observation is the fact that the *average* markups among the different groups of stores are quite similar despite the fact these are differences in the percentage markups adopted by individual stores in each group. The composite markups are given in Table 3. Other than the composite markup on fresh finfish, the average markups of specialty markets are not shown in Table 3 since there are so few specialty markets offering either frozen prepared or canned fish.

SOURCES OF SUPPLY

The 110 retailers in this study obtain their fish from 24 different wholesale sources, ranging from specialized fish distributors to general line grocery wholesalers, or from their own central chain store warehouses and other retailers. Two very small grocers, for example, purchase their canned tuna from larger retailers when the latter run specials because the minimum order quantity exceeds the inventory they want to carry. All but two of the 24 wholesale sources are situated within the state of Ohio.

The chain stores ordinarily secure canned, frozen, and fresh fish from their company's warehouse. Some of the chains' warehouses, however, do not handle fresh fish. If a meat manager insists on carrying fresh fish under these circumstances, he must obtain it from an independent supplier. Affiliated retailers usually operate in the same manner, that is, they typically get their canned and frozen fish from their sponsor's warehouse and their fresh fish from a nonaffiliated independent wholesaler. Nonaffiliated independent retailers procure canned fish from general line grocery wholesalers and their fresh fish from specialized distributors. Frozen fish may come from either the general line wholesaler or the specialty house. Once the liaison is established with a source of supply, however, few independent retailers will buy fresh or frozen finfish and shellfish from different wholesalers simultaneously.

Table 3.—Average percentage markups on retail selling price by type of store and form of fish handled.

Type of Store	Whole or Processed				Prepared				Canned
	Fresh		Frozen		Fresh		Frozen		
	Fin	Shell	Fin	Shell	Fin	Shell	Fin	Shell	
A. *General Line* Group									
1 (Sales to $99,999)			23.0	22.3			21.5	22.8	20.8
2. ($100,000 to $499,999)	26.2	30.0	26.1	23.7			23.7	23.9	21.0
3. ($500,000 to $999,999)	25.6	23.3	26.0	25.0	25.0		24.4	25.0	21.5
4. ($1,000,000 and over)	25.6	24.1	25.1	25.1	25.6	25.0	25.1	25.1	17.5
B. *Specialty Line* Group									
1. (Sales to $99,999)	27.1								
2. ($100,000 to $499,999)									

TRENDS IN RETAILERS' FISH SALES 1966-1971

Retailers were asked if their fresh, frozen, and canned fish sales had increased, remained the same, or declined since 1966. They were also asked why they thought these trends had occurred.

Trends in Fresh Fish Sales

Examination of the replies reveals that more retailers reported declines in sales of fresh, frozen, and canned fish than those who reported there was either no change or an increase in sales. In contrast to frozen and canned fish, however, fresh fish was the only type of fish for which over half of the interviewees (57 percent) indicated sales were down. Among the remaining stores handling fresh fish, 27 percent said sales were stable while 16 percent thought their sales had increased. The reasons related by retailers for the increase in fresh fish sales were:

(1) fresh fish is cheaper than beef;
(2) the store expanded its offerings of fresh fish;
(3) more dieters;
(4) change in community's ethnic structure.

Retailers with no change in fresh fish sales had no explanation as to why sales were stable. Combinations of reasons were given by those whose sales had declined. Seventy-six percent, for example, pointed to pollution scares, 36 percent mentioned higher price, while 28 percent cited the change in the dietary requirements of the Catholic Church.

Trends in Frozen Fish Sales

Forty percent of the merchants

with frozen fish reported sales declines. Thirty percent said sales were the same while the remaining 30 percent said frozen fish sales were up. The increase in frozen fish sales was attributed primarily to:

(1) enlarged offerings (45 percent of stores);
(2) cheaper than beef (18 percent);
(3) cheaper than fresh fish (7 percent);
(4) safer than fresh fish (7 percent);
(5) convenient meal (7 percent);
(6) more dieters (7 percent).

Stores whose sales had remained the same offered little or no explanation as to why sales had not changed, with the exception of a few managers who thought pollution scares dampened any potential increase in frozen fish sales. Those reporting sales declines mentioned the same kind of combinations of reasons given for the drop in sales of fresh fish, that is:

(1) pollution scares (70 percent);
(2) higher price (28 percent);
(3) changes in the dietary requirements of the Catholic Church (33 percent).

Trends in Canned Fish Sales

Since the United States had experienced a substantial recall of contaminated tuna at the time the survey was conducted, it is not surprising to learn that 44 percent of the retailers reported a drop in canned fish sales. Thirty-six percent, on the other hand, said sales had not changed while 20 percent indicated their canned fish sales had increased. The increment in sales was attributed to:

(1) expanded canned fish offerings by the store;
(2) the increase in number of dieters;
(3) the fact canned fish is a nutritous, inexpensive meal.

Pollution was given as the reason why canned fish sales had neither increased nor decreased. That is to say, consumers either were reluctant to eat more canned fish or sales of canned fish had returned to their normal plateau after the initial impact of a pollution warning. Lastly, the same combinations of factors emerge as explanations for the decline in sales:

(1) pollution scares (63 percent);
(2) higher price (30 percent);
(3) changes in the dietary requirements of the Catholic Church (26 percent).

Summary of Sales Trends

In summary, when all forms of fish are considered as a unit, the three factors to which increments in sales are attributed most often are:

(1) the expanded offerings of that form of fish by the store;
(2) the fact that fish is cheaper than beef;
(3) the growth in number of dieters.

Conversely, declines in sales are mostly attributed to:

(1) apprehension by consumers of the effects of pollution;
(2) the consistent increase in retail price;
(3) the change in dietary requirements of the Catholic Church.

Few retailers offered an explanation for stable sales. Those who did, however, mentioned pollution scares. These respondents felt consumers were either reluctant to eat larger quantities of fish or had just returned to their regular consumption patterns after a pollution alert.

RETAILERS' PREFERENCES IN HANDLING FRESH VERSUS FROZEN FISH

Preferences

After relating their sales trends for fresh, frozen and canned fish, retailers were next asked whether they preferred handling fresh or frozen fish. Tabulation of the responses in Table 4 shows a strong preference for frozen fish. Surprisingly, only 40 percent of the specialty markets preferred fresh fish while 60 percent were either indifferent or preferred handling frozen fish.

Reasons Why

Retailers who rated the handling of fresh fish above frozen fish did so because they thought consumers generally preferred fresh fish. This reason was given by 12 respondents. Similarly, six respondents specifically referred to the fact consumers preferred fresh fish because it tasted better or represented better quality. Two retailers preferred fresh fish to frozen fish because it was more profitable. Lastly, one respondent also said fresh was easier to handle than frozen fish. Recasting these responses in terms of supplier versus buyer preferences, 14 percent of the reasons were associated with profitability to retailers or ease of handling whereas 86 percent were attributed to consumer preference, taste, and quality.

The situation is reversed for frozen fish. Seventy-one percent of the responses were essentially ease of handling responses. For example, "easier to handle in store" was specifically mentioned 28 times. "No facilities for fresh fish" and "less spoilage or waste" were each mentioned 14 times. Similarly, such reasons as "no odor," "more dependable supply" and "more profitable" are also retailers' preferences rather than consumers' preferences. From the consumers' point of

Table 4.—Retailers' preference in handling fresh vs. frozen fish.

	Preferences					
	General Line Groups				Specialty	Total
Form of Fish	1	2	3	4		
Fresh	1	2	7	5	5	20
Frozen	16	23	10	17	3	69
No Preference	12*	1	1	3	4	21

*Handled canned only

view, "consumers prefer frozen" was mentioned nine times; "cheaper than fresh," ten times; "a better quality product," five times; and "people want convenience," was mentioned once.

There is an intriguing duplication among retailers' preferences of fresh versus frozen fish. For instance, the responses "better quality," "more profitable," "easier to handle," and "consumers' preference" appear on both lists of reasons why retailers prefer handling either fresh or frozen fish. Retailers evidently have not resolved such issues as (a) which form of fish is better in quality, (b) easier to handle, or (c) more profitable. On this latter point, moreover, two specialty markets specifically said there was no profit in fresh fish although they sold it because customers preferred fresh fish.

BRANDING

Because no published information was found concerning types of brands associated with the merchandising of fish, several questions in the exploratory survey probed in this area. Basically, there are two types of brands. Processors' brands are the brand names attached to the product by the processing companies. Processors' brands are also known as national brands. Store or private brands, on the other hand, are brand names sponsored by resellers.

Fresh Fish Brands

Fresh fish is unique due to the absence of brand names. Some stores sell fresh fish from trays while others offer it on a prepacked, prepriced basis. Managers selling prepacked, prepriced fresh fish occasionally insisted their fresh fish carried a store brand because the store's reputation was behind the product and the price labels contained the store's name as well as species. Since these labels are designed to convey primarily the price of the product or to identify the species rather than promote it, they clearly are not store brands.

Frozen and Canned Fish Brands

Frozen and canned fish, in contrast to fresh fish, are heavily branded products. Turning to frozen fish, processors' brands are more prevalent than stores' brands. Moreover, where stores' brands are carried, they usually are offered along with national brands. With the exception of the small group 1 general line retailers and the specialty markets, for example, 35 to 45 percent of the stores in groups 2, 3, and 4 handle their own brands as well as processors' brands.

The patterns for canned fish are very similar to frozen fish. No specialty markets and only two small group 1 general line retailers, for example, offer stores' brands. All group 2, 3, and 4 grocery retailers with their own brands of canned fish dual them with processors' brands. The distinct difference in branding practices between frozen and canned fish is the fact unbranded frozen fish was found in some group 3 and 4 stores, whereas no one handled unbranded canned fish.

Customers' Brand Preference

When asked which brand they thought their customers preferred, some store managers reported their customers might prefer recognized processors' brands of fresh fish. A lesser number who insisted their stores' reputation and price labels were really store brands, thought their customers preferred this practice. A majority of the respondents, nonetheless, said customers had no labeling or brand preference as far as fresh fish was concerned.

Comments about customers' brand preferences for frozen and canned fish, however, approached unanimity. No one said customers preferred their store's brands of canned fish to processors' brands, and only two thought their customers preferred their own brand of frozen fish to processors' brands, despite the fact no fewer than 30 percent of these stores in groups 2, 3, and 4 offered some variety of frozen or canned fish under their own labels.

Finally, most respondents are of the opinion that additional branding would have no impact on the sale of fish. Among the minority who believe additional branding would increase sales, there is the opinion that the impact on sales of fresh fish would be greater than on frozen or canned fish. Respondents who view additional branding in a positive manner are predominantly managers of the largest group 4 general line stores.

PROMOTIONAL PRACTICES

Promotional practices of retailers were explored on the basis of: (a) external promotion designed to attract customers to the store for fish and, (b) internal promotion designed to stimulate fish sales at point of purchase, that is, the store.

External Promotion

The promotional medium utilized to bring people to the store is essentially the newspaper. Most of the newspaper advertisements, as a matter of fact, are sponsored by affiliated groups or chain stores. In descending order, the other media mentioned are handbills, home mailers, radio, and TV. With one exception, only the general line grocers with sales of $1 million or more per annum resort to radio or TV. On a category-by-category basis, 80 percent of the specialty fish or meat markets as well as the general line grocers with annual sales under $100,000 engage in no external advertising of fish. Neither do 60 percent of the general line stores with sales in the $500,000 to $999,999 range. Among the smaller general line grocers with annual sales of $100,000 to

$499,999, however, only 50 percent indicate they do not promote fish externally. Although one would assume all general line grocery outlets with $1 million or more in annual sales would advertise fish, 5 percent report no advertising of fish. Finally, the secondary role of fresh fish is highlighted again by the fact the relative number of general line retailers in each sales category who advertise fresh fish is less than the proportion who advertise frozen or canned fish.

Instore Promotion

The instore promotional activities for fish follow closely the patterns found for external promotion. First, method—stock display—to stimulate fish sales. The other promotional devices used in conjunction with merchandise displays by some of the stores, however, are special price promotions, interior store signs, and window posters. All of the specialty fish or meat markets as well as over 90 percent of the smallest general line grocers identified stock displays exclusively as their point of purchase promotional activity. Sixty percent of the group 2 and group 3 general line grocers also did so. Once again, the largest retailers were the ones who utilized a variety of instore promotional techniques. Merely 8 percent of the stores in group 4, for example, said they depended on stock displays only. Similarly, the same relative emphasis on promoting frozen or canned fish rather than fresh fish is evident internally as it was externally.

RETAILERS' OPINIONS

Purchasers of fresh fish are described by retailers as:

(1) older families;

(2) either of higher or lower but not middle income;

(3) Catholics;

(4) Blacks, Jews, or ethnic groups;

(5) dieting, health-conscious families;

(6) people who grew up near water where they had access to fresh fish. Retailers believe these people prefer fresh fish because the purchasers think fresh fish either tastes better or is better in quality.

Frozen fish buyers, on the other hand, are described by retailers as:

(1) younger families;

(2) larger size families;

(3) middle to low income families;

(4) families whose wives work and/or desire convenience.

Frozen fish purchasers are also identified as "all types of families" more often than by religious or racial background. Retailers think consumers who prefer frozen fish to fresh fish do so because:

(1) frozen fish is more convenient to use, that is, ready to cook or heat;

(2) it is an inexpensive meal;

(3) frozen fish is easy to store and use any time during the week;

(4) a large variety and selection is always available at stores;

(5) some consumers consider taste of frozen fish as better than that of fresh fish.

Terms used by retailers to describe canned fish customers are similar to those associated with frozen fish buyers. For example, typical customers are identified as:

(1) younger families;

(2) larger size families;

(3) low income or welfare families;

(4) families whose wives work.

A preponderant number of retailers, however, view canned fish as a standard grocery item purchased by all types of families because it is convenient to use and ready to eat. Many retailers further mentioned that this is the only way to obtain species such as tuna, sardines, salmon, and mackerel. Finally, several retailers commented that people who dislike fish (fresh or frozen) purchase canned varieties because they do not identify canned species as fish.

FRESH FISH PROCUREMENT PRACTICES

Ordering Fresh Fish

Three out of four retailers selling fresh fish either contact the wholesaler directly whenever they need fresh fish or they place their orders with the wholesalers' salesmen who call regularly at their stores. Along with the independents and affiliated stores, many supermarkets also procure their fresh fish this way since less than one-half of chain stores' warehouses handle fresh fish. These chains say fresh fish is too perishable, too inconvenient, and too small in sales volume to handle. They prefer that their units offering fresh fish buy it directly from local wholesalers.

Delivery

Sixty percent of the retailers take delivery of fresh fish once a week, generally at midweek for the weekend trade, whereas 40 percent offer fresh fish daily and stock as needed. Over 60 percent report wholesalers make delivery within 24 hours. Ten of the 16 stores without 24-hour delivery service are chain store units that obtain fresh fish from their company's warehouses, usually on a weekly delivery basis. It is not surprising, therefore, to find that only four of the 42 stores selling fresh fish express any interest in a 24-hour delivery time proposal.

Species Handled

The species of fresh fish carried by 20 percent or more of the stores (in descending order) are: perch (73 percent); haddock (50 percent); pike (30 percent); sole (26 percent); whiting (21 percent); oysters (21 percent); and bass (20 percent). Thirty-three of the 42 retailers select the species carried according to customers' preference or sales experience. Similarly, two retailers report they try additional

species each month to provide greater variety and gauge sales experience. Three retailers handle whatever their chain warehouse or supplier have available. Three additional firms rely on their meat managers to decide what to carry (presumedly customers' preference or sales experience) while the last retailer uses resale price as his guide line. It is further evident from the interviews that a majority of the retailers envision no effect on sales if they could order particular species from wholesalers.

Underutilized Species

A list of 13 underutilized species, developed with the assistance of several executives from the Office of Sea Grant, was presented to retailers handling fresh fish to ascertain if they could profitably sell those species. Of the 13 species listed, 50 percent or more of the retailers thought they might profitably handle four—silver hake, mackerel, Pacific cod, and catfish. Mackerel was the most widely recognized species on the list. Seventeen of the 27 retailers who said they could handle mackerel profitably, however, viewed it as a canned product. Nearly all of the favorable respondents considered Pacific cod a frozen product, while 55 percent believed silver hake would sell better in frozen form and catfish in fresh form.

The "No" respondents consisted of retailers who believed they could not handle the species profitably plus those who were unfamiliar with the species. Some respondents, for example, said they knew little or nothing about pollock. Others considered pollock a prepared frozen fish used in fish sandwiches by drive-ins or by schools for lunch programs. Northern shrimp was unprofitable because it was "too expensive" or "too small." Tanner crab was "too expensive," lacking in "eye appeal," or "spoiled too fast." Those who reacted negatively to Pacific cod did so because "the taste is too strong." A substantial number of interviewees had never heard of "blue" mussels or "calico" scallops. Nevertheless, the basic reason why most retailers would not handle these species was expressed in terms of "no demand." Until consumers were familiar with these species and knew how to prepare them, these retailers asserted they would not handle them.

PROBLEMS OF RETAILERS HANDLING FRESH FISH

Surprisingly only 13 of the 110 retailers asserted they had any problems handling fish. Furthermore, only 10 of the 42 retailers selling fresh fish mentioned spoilage as a particular problem. Similarly, despite the fact 92 of the 110 retailers stocked some form of frozen fish, merely two retailers put forth problems associated with frozen fish, namely, freezer burn and thawing. Lastly, foreign material in canned fish was given by one retailer as a problem he had with canned fish.

Due to the perishability of fresh fish, the retailers who reported spoilage problems said they ordered minimum quantities as needed and attempted to sell their inventory in two or three days. As a matter of fact, two retailers commented it was better to have too little than too much fresh fish on hand. Two retailers noted that they kept fresh fish heavily iced to reduce spoilage, while a couple more retailers used lemon to kill the smell.

As a group, they further proposed that fresh fish move to the store faster for longer shelf life. Several also suggested wholesalers either permit smaller orders or refrigerate fresh fish better. Rinsing fresh fish after two days; freezing left-over fish; ceasing the use of cardboard and plastic that dry out fish; and stop handling fresh fish were also given as means of preventing spoilage.

Although 14 of the 42 retailers had no problems in selling fresh fish versus fresh meat, four of the 14 "no problem" retailers were specialty fish markets handling fish only. Aside from this group, the problems described by retailers selling both fresh fish and meat fall into two categories. The first category represents handling problems such as the fact fresh fish leaks or smells and must be separated from fresh meat, especially chicken. Similarly, fresh fish must be sold faster than meat; keeping fish iced is messy; it is more difficult than meat to display attractively; lights dry out fresh fish faster than meat; and leftover meat can be sold as hamburger if necessary, whereas fresh fish can only be frozen. The second group of problems is essentially sales volume oriented. Fear of pollution and consumer ignorance of nutritional value, for example, tend to depress sales of fresh fish. Fresh fish, moreover, sells generally on Thursday or Friday, whereas meat sells every day. Lastly, the uncertain supply of fresh fish in contrast with the availability of meat tends to reduce fresh fish sales.

MFR Paper 1025. From Marine Fisheries Review, *Vol. 35, No. 12, December 1973. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*

NOAA/NMFS Developments

Gehringer Is Named Deputy Director of NMFS

Jack W. Gehringer has been named Deputy Director of the National Marine Fisheries Service, the Commerce Department's National Oceanic and Atmospheric Administration has announced.

Since 1972, Mr. Gehringer has been director of the Fisheries Service southeast region, headquartered in St. Petersburg, Fla., with responsibility for certain Federal fisheries activities in 17 states, plus Puerto Rico and the Virgin Islands.


Gehringer

As Deputy Director, he will work with NMFS Director Robert W. Schoning in planning, developing, coordinating, and administering the Service's diverse research efforts and fisheries programs.

Mr. Schoning said the Deputy also works closely with the Director in maintaining primary supervision over day-to-day functions of the Service and about 1,700 full-time employees throughout the country. The primary goals of the NMFS are to promote full economic and safe utilization of fisheries resources; to conserve and allocate fisheries resources of interest to the people of the United States; to increase our fisheries resources through the use of hatcheries and aquaculture; to ensure that adequate consideration is given to the requirements of living marine resources in proposed environmental changes and to protect and conserve marine mammals in order to maintain the health and stability of the marine ecosystem.

Mr. Schoning said: "Jack Gehringer was chosen for this important post because of his broad experience and his record as a highly capable and effective leader. He is widely known in fisheries circles in the United States and abroad and is the author or co-author of numerous scientific publications on various fisheries topics."

Mr. Gehringer joined the Federal fisheries agency in 1950 as a marine biologist with the Galveston, Tex., laboratory. Two years later, he was transferred to the Brunswick, Ga., laboratory where he was a program leader, assistant laboratory director, and later acting laboratory director until 1969. He then served as acting deputy regional director of the Southeast Region, and in 1970 was named associate regional director.

Mr. Gehringer received his B.S. degree in fisheries from Colorado A&M College in 1950 and is a member of several professional fisheries societies and institutes. He is married to the former Virginia Pennoyer, and they have three children.

Bob Finley Garners High NOAA Award

Bob E. Finley, Chief of the National Marine Fisheries Service's National Marketing Services Office, Chicago, Ill., is one of the winners of the six 1973 NOAA Awards for outstanding contributions to NOAA programs. Each of the six men receives a plaque and one thousand dollars.

Finley is one of three to receive the high NOAA honor for public service. His award was presented for pioneering a "new look" in the consumer education materials produced by the National Marketing Services Office.

Mr. Finley initiated and produced a popular series of full-color education posters on the fish of various regions. He also developed a bilingual kit in English and Spanish, designed for training low-income groups in the use of fishery products to obtain maximum nutrition at the lowest possible cost. The new formats, unique style, and added utility of these materials has increased their acceptance by the mass media and the public.

New Ocean Instrument Check Centers Open

The opening on the Pacific coast of two regional calibration centers for oceanographic instrumentation has been announced by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce. The centers are located at Bellevue, Wash., a suburb of Seattle, and San Diego, Calif. Both are units of NOAA's National Oceanographic Instrumentation Center in Washington, D.C.

The task of the Northwest Regional Calibration Center and the Southwest Regional Calibration Center is to ensure high standards of data quality through the testing and calibration of oceanographic instruments and related equipment. Their facilities and services are available on a reimbursable basis to federal, state and local government agencies, academic institutions, and industrial concerns. The west coast facilities will materially reduce transportation costs and calibration turnaround time for instruments used in Pacific oceanographic activities, which previously were shipped to the main NOIC office in Washington, D.C. A third regional center is located near Bay St. Louis, Miss.

Both Pacific coast facilities are being operated for NOAA under contract, that in Bellevue by the Oceanographic Institute of Washington and the San Diego facility by the Marine Physical Laboratory of the University of California's Scripps Institution of Oceanography.

The San Diego facility is located at 9284 Balboa Avenue. Its services are available to the oceanographic and environmental science community in California and Hawaii.

The Bellevue facility is located at 300—120th Avenue, N.E., Benaroya Business Park, Building 6. Its servicing area embraces Alaska, British Columbia, Idaho, Montana, Washington, Oregon, and three northwestern coastal counties of California.

Shomura Heads NMFS Honolulu Laboratory

Richard S. Shomura, who received his Master's Degree at the University of Hawaii in 1960, has returned to the Islands as Director of the National Marine Fisheries Service, Southwest Fisheries Center, Honolulu Laboratory. His appointment, announced by Center Director Dr. Brian J. Rothschild, became effective September 16.

Shomura

Since leaving Hawaii in 1970, Mr. Shomura has served NMFS as Associate Director for Fisheries at the Regional Office in Terminal Island, Calif. and later as Director of the Tiburon (Calif.) Fisheries Laboratory.

A native of Honolulu, he has been with NMFS (and its predecessor, the Bureau of Commercial Fisheries, Department of the Interior) since 1950. This background of more than 20 years experience in tuna and tuna-related studies makes him an exceptional choice for this important post, said Dr. Rothschild.

The valuable food fish skipjack tuna (*Katsuwonus pelamis*) is presently regarded by science and industry as an important underutilized species, explained Mr. Shomura. An immediate intention of the Honolulu Laboratory is to intensify its studies of skipjack. "We plan to stress assessment of the resource, fishery analysis, bait fishery development, and the development of a possible purse seine fishery," he said. The Honolulu Laboratory will also increase its investigation of oceanic recreational fisheries. Mr. Shomura replaces Dr. Frank J. Hester.

NMFS Gets New Mobile Laboratory

Delivery of a specially equipped mobile laboratory designed primarily to inspect seafood processing plants for hygienic and other conditions has been accepted by the Commerce Department's National Oceanic and Atmospheric Administration.

The van, based at the NMFS technology laboratory at Pascagoula, Miss., will be used principally at fisheries processing plants that use the voluntary fisheries inspection program conducted by NOAA's National Marine Fisheries Service. Most frequent uses for the van, according to E. Spencer Garrett, laboratory director, will be for research on fish processing, for inspection and quality control, and for marine advisory services.

Dubbed PRIME/Van (for "Processing Research, Inspection, and Marine Extension") the laboratory-on-wheels is self-contained, with sufficient auxiliary power generating capacity to handle all electrical systems, including air conditioners. As presently equipped, it weighs about 12 tons.

The PRIME/Van is another step toward improving the effectiveness of the Fisheries Inspection Program of the Department of Commerce. With the PRIME/Van, numerous inspection and testing services can now be carried out on the scene without having to take samples to laboratories for analysis. Testing for spoilage and examining environmental sanitation of processing facilities are among other capabilities of the vehicle. The mobility factor can also save time for both the plant managers and the NMFS inspectors.

When not engaged in inspection services, the van can readily be adapted to other uses such as testing the safety of drinking water supplies during natural disasters or testing water quality before, during, or after a fish kill.

Mr. Garrett said the vehicle will also be available for demonstration seminars dealing with fisheries product inspection and will serve as a valuable educational tool in teaching the interested public via Sea Grant universities and other groups how inspection is carried out under the NMFS program.

Publications

Recent NMFS Scientific Publications

NOAA Technical Report NMFS SSRF-669. Eber, L.E., **"Subpoint prediction for direct readout meteorological satellites."** August 1973, iii + 7 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

The National Environmental Satellite Service (NESS) provides orbital information on meteorological satellites with direct transmission systems, through APT (Automatic Picture Transmission) Predict messages sent over standard weather communications networks. With periodic access to this information. operators of independent APT ground receiving stations can extrapolate, by means of nodal period and nodal increment, to determine future orbits within receiving range of their station. A technique for the prediction of subpoint location along an orbit as a function of time after ascending node was developed from consideration of Kepler's laws and derived expressions for the force due to the earth's gravitational potential. Subpoint latitudes and longitudes computed by this technique are within 0.1 degree of those given in NESS prediction.

NOAA Technical Report NMFS SSRF-672. Tagatz, Marlin E., and E. Peter H. Wilkens, **"Seasonal occurrence of young Gulf menhaden and other fishes in a northwestern Florida estuary."** August 1973, iii + 14 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

ABSTRACT

Gulf menhaden, *Brevoortia patronus*, and other species of fishes were collected by plankton net, seine, and surface trawl from Pensacola Bay, East Bay, and East Bay River from December 1969 to October 1971. Relative abundance, distribution, and relative growth of menhaden are given from the time they enter the estuary as larvae in December to the time they emigrate to the Gulf of Mexico as juveniles in September.

Eighty-four species of fishes, representing 46 families, were captured. The number and length range of each species by month are presented for the areas from which it was caught. Also included are the salinity and temperature ranges at capture. Four species were not previously recorded from Pensacola estuaries.

NOAA Technical Report NMFS CIRC-384. Moul, Edwin T., **"Marine flora and fauna of the Northeastern United States. Higher plants of the marine fringe."** September 1973, iii + 60 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402—Price 65 cents.

ABSTRACT

The common higher plants of the beaches, dunes, morainal cliffs, and tidal marshes of Southern New England are treated in an illustrated key, using only vegetative characters. Both scientific and common names are given. Habitat lists of the plants are included, presenting to the investigator the association of plants as they occur in nature. The range of each plant along the Atlantic coast is designated. A glossary of terms is included.

Fishery Facts-5. Dudley, Shearon, J. T. Graikoski, H. L. Seagran, and Paul M. Earl, **"Sportsman's guide to handling, smoking, and preserving coho salmon."** June 1973, iii + 28 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402—Price 25 cents PPD, 15 cents BKS.

No Abstract

Circular 330, Volume 7. Love, Cuthbert M. (editor), **"EASTROPAC Atlas."** July 1973, vii + 145 figures. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402—Price $4.75 per volume.

ABSTRACT

This atlas contains charts depicting the distribution of physical, chemical, and biological oceanographic properties and associated meteorological properties observed during EASTROPAC. EASTROPAC was an international cooperative investigation of the eastern tropical Pacific Ocean (20° N. to 20° S., and from the west coasts of the American continents to 119°W.) which was intended to provide data necessary for a more effective use of the marine resources of the area, especially tropical tunas, and also to increase knowledge of the ocean circulation, air-sea interaction, and ecology. The Bureau of Commercial Fisheries (now National Marine Fisheries Service) was the coordinating agency. The field work, from February 1967 through March 1968, was divided into seven 2-month cruise periods. During each cruise period one or more ships were operating in the study area.

On completion of the field work the data seemed too numerous for a classical data report. Instead, it was decided to produce an 11-volume atlas of the results, with five volumes containing physical oceanographic and meteorological data from the principal participating ships, five volumes containing biological and nutrient chemistry data from the same ships, and one volume containing all data from Latin American cooperating ships and ships of opportunity. Extensive use was made of a computer and automatic plotter in preparation of the atlas charts. Methods used to collect and process the data upon which the atlas is based are described in detail by the contributors of the following categories of chart: temperature, salinity, and derived quantities; thickness of the upper mixed layer; dissolved oxygen; meteorology; nutrient chemistry; phytoplankton standing stocks and production; zooplankton and fish larvae; micronekton; birds, fish schools, and marine mammals.

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Editor's Comments

Kamaboko and Salm-on

• Kamaboko, if it is familiar at all to many Americans, is known as that greyish-white Japanese delicacy, prettily tinted red or green on the top and sides, that looks as if it should taste sweet but doesn't. It has a mildly salty, fishy tang to it, and this comes as a not always agreeable surprise, much as if a piece of cheese were masquerading as a chocolate bar. But, our three lead articles point out, there are many forms of kamaboko. A type I particularly like is that which is deep-fried. This not only tastes very good, but it *looks* right—a pleasant, crusty brown.

Kamaboko, of course, is a staple of the Japanese diet. As our authors demonstrate, the making of it is a big business in Japan and one that may offer opportunities to the U.S. fishing industry to earn a good many yen.

• One of the peskiest words in the fisheries literature is "salmon." To editors it appears that in any given scientific paper on salmon, at least 15 percent of the lines of type will end with the first syllable of the word. And there lies the trouble. According to the dictionaries, the correct division of the word is after the "m"—that is, salm-on. But almost any well-trained typist or typesetter (and most unwary editors) will divide it after the "l", following the established principles of English word division. Very frustrating for all concerned. After marking ten or twenty such incorrect divisions in proof recently, I got to wondering why the division should fall this way, particularly when Salmonidae, the family of fishes to which the salmons belong, is, again according to the dictionary, divided after the "l": Sal-monidae. It all seems rather arbitrary. But Rae Mitsuoka, an editor at the NMFS Northwest Fisheries Center, came up with what seems a reasonable suggestion: the "l" being silent in "salmon," the word is divided at the end of the first pronounced syllable. The "l" in Salmonidae, on the other hand, is pronounced, and hence the exasperatingly variant word division.

Looking through the "salm-" entries in the dictionary, I discovered something else I didn't know. Salmonella, another word fairly common in fisheries literature, has nothing at all to do with either salm-on or Salmonidae. It owes its name to Daniel E. Salmon, an American veterinarian. It is divided after the "l."

• The Norway Trade News carried an item recently that fresh tuna are being flown from Norway to Japan. There they are used for sashimi. There were three Japanese inspectors in Norway last summer supervising the packing and dispatch of the fish. No prices were given.

• Recently I read a manuscript for a forthcoming number of the *Fishery Bulletin* which dealt with a computer simulation of the Bristol Bay salmon fishery. To someone like me, who has trouble keeping a checkbook straight, the paper was rather overwhelmingly mathematical. But one number sticks in the mind. The author points out that—in his model—the manager has a choice of three distinct strategies available each day that the fishery is open. The author points out that there are thus 3^m separate courses of action that may be pursued in a fishing season m days long. If the season lasts 20 days, the number of allowable strategies is 3^{20}. "This," he says, "is a number not to be taken lightly." Nor is it: 3^{20} is approximately one billion. One interesting thing about these computer studies—and they are very useful, indeed—is that they are giving us better measures of the capacities of the human mind. A billion decisions in 20 days: perhaps we are cleverer than we know.

• Although my name appears in perhaps overbold type on the inside front cover as the editor of *Marine Fisheries Review*, it would be presumptuous to say that I alone determine the content of the publication. That to some extent is decided by the authors of the individual papers, who are under no pressure to submit them for publication here, and to perhaps to an even greater degree by certain officials of the National Marine Fisheries Service whose duties include the reviewing of all manuscripts produced by our people. These include our Associate and Assistant Directors, Center Directors, and some others. They are required to decide whether manuscript is factually accurate and worth publishing. They exercise this prerogative, I think, responsibly. As for papers submitted by persons other than members of the NMFS staff, they are given what is known in science as "peer review." Each such manuscript is sent to a competent authority and it is he who decides whether the paper is worthy of publication. There is thus an "invisible" editorial board working to make *Marine Fisheries Review* as accurate and responsible as is possible.

• One of our NMFS publications this month should have wide appeal. This is Fishery Facts-5, an NMFS Extension Publication, "Sportsman's Guide to Handling, Smoking, and Preserving Coho Salmon," by Shearon Dudley, J. T. Graikoski, H. L. Seagran, and Paul M. Earl. With the successful introduction of coho into the Great Lakes and more recently New England (see the October number of MFR), this publication should be of uncommon interest to sportsmen in the Pacific Northwest, the Midwest, and the Northeast. The publication has step-by-step illustrations of the processes involved in preparing coho salmon for the table.

T.A.M.

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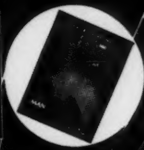

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